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A PALEOZOIC SECTION
IN
SOUTH-CENTRAL PENNSYLVANIA

By

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and

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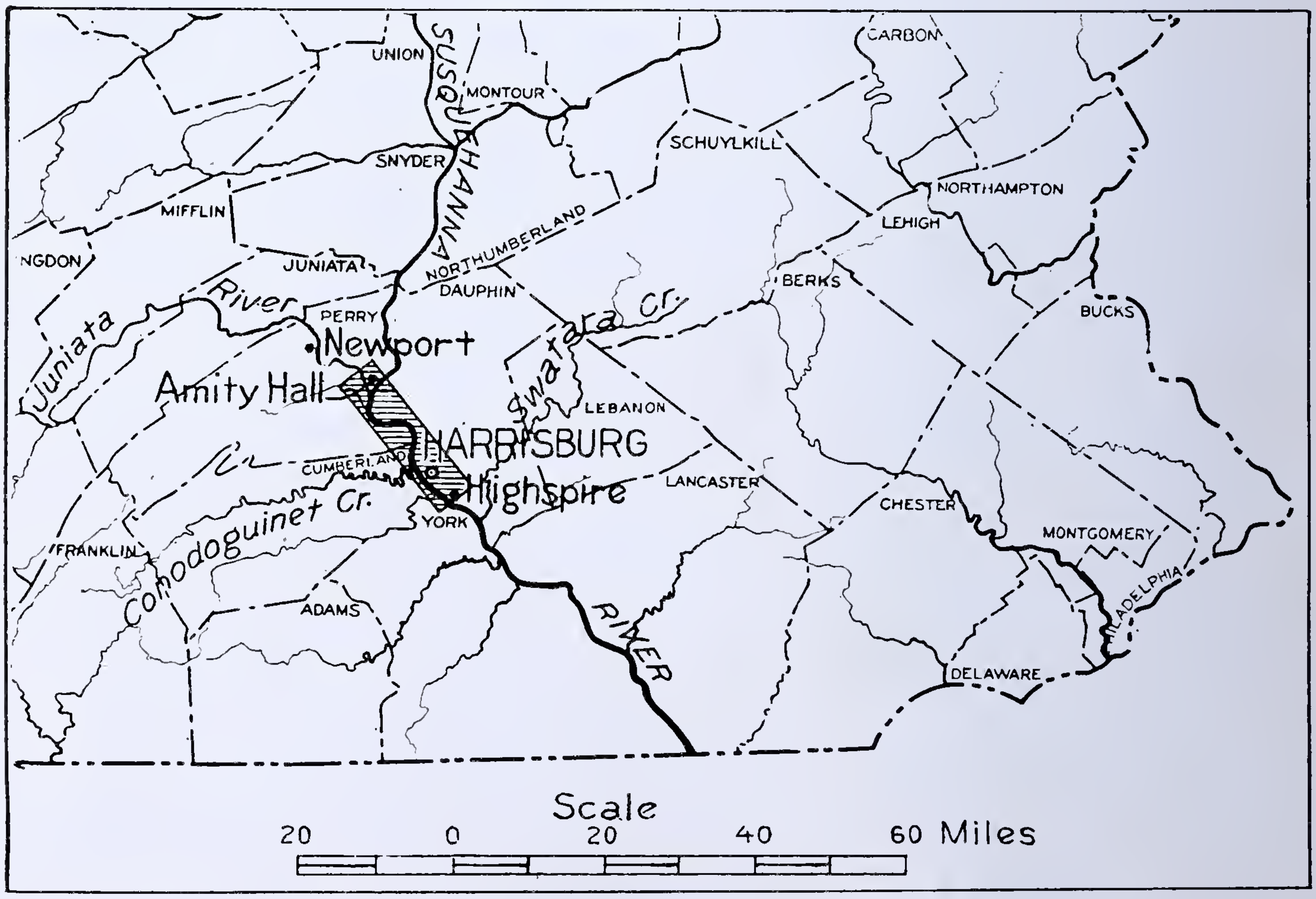

Figure 1. Key map showing location of section.

A PALEOZOIC SECTION IN SOUTH-CENTRAL PENNSYLVANIA

By BRADFORD WILLARD *and* ARTHUR B. CLEAVES

INTRODUCTION

LOCATION

The Harrisburg area here discussed consists of a narrow, north-south belt including the valleys of the Susquehanna and Juniata rivers in south-central Pennsylvania from Highspire south of Harrisburg, northward along the Susquehanna to its confluence with the Juniata at Clarks Ferry and thence up the Juniata Valley past Amity Hall to Half Falls Mountain below Newport. The rock sequence will be referred to as the Harrisburg section.

IMPORTANCE OF SECTION

Interest in the geology of this area is of long standing. The First Pennsylvania Geological Survey made careful studies here.[1] These were amplified by the work of the Second Pennsylvania Survey,[2] particularly the report by Claypole.[3] More recently, several papers have appeared treating with particular parts of the area.[4] Much of the present report is based upon the studies conducted by the junior author who, during the 1931 and 1932 field seasons, made a detailed study of the New Bloomfield quadrangle.[5] The data which he then accumulated are partly incorporated in the following observations. The area has also been given particular attention by the senior author, but only as a part of his more extended work on the Devonian and Mississippian of Pennsylvania. We make no claim to presenting anything strikingly new. Rather, this paper is a compilation and review of many scattered facts, both published and unpublished, which have not before been assembled.

The importance of this section depends partly upon its completeness. It includes in a linear distance of only 25 miles, an almost uninterrupted sequence embracing formations from the lower Ordovician (Canadian) through the Triassic red beds, Triassic igneous intrusions and unconsolidated Pleistocene and Recent sediments. It is also an important key to the stratigraphy of much of the Paleozoic of the State. The structural geology and physiography are significant. The Pennsylvania Topographic and Geologic Survey has for some years made a practice of using the section to demonstrate the geology of this part of the State. Local groups of amateur geologists, Boy and Girl Scout troops, science teachers, students from universities and colleges, and casual visiting geologists have been conducted over the region. It was included among excursions of the International Geological Congress in 1933.[6] The Field Conference of Pennsylvania Geologists visited the section the same year.[7] In 1936 the principal field trip offered the guests at the Centennial Celebration of the First Pennsylvania Geological Survey went over this ground.[8] Because of this importance and interest, a description of the strata and a guide to the more significant points are given.

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[1] Henry D. Rogers: Geology of Pennsylvania (1858).

[2] J. P. Lesley: A summary description of the Geology of Pennsylvania; Pa. Second Geol. Surv. (1892-1895).

[3] E. W. Claypole: A preliminary report on the palaeontology of Perry County; Pa. Second Geol. Surv., vol. F2 (1885).

[4] Arthur B. Cleaves: Structural geology of the New Bloomfield quadrangle, Pennsylvania; Pa. Acad. Sci., pr. vol. 9 (1935) pp. 141-146.

Arthur B. Cleaves: Middle Devonian branchiopod from Perry County, Pennsylvania; Jour. of Paleontology, vol. 9 (1935), p. 6.

G. W. Stose: Unconformity at the base of the Silurian in southeastern Pennsylvania; Geol. Soc. Am., Bull., vol. 41 (1930) pp. 629-658.

C. K. Swartz and F. M. Swartz, Early Silurian formations in southeastern Pennsylvania: Geol. Soc. Am., Bull., vol. 42 (1931) pp. 621-662.

Bradford Willard: Oriskany at Susquehanna Gap, Pennsylvania; Geol. Soc. Am., Bull., vol. 42 (1931) pp. 697-706. Since this paper appeared, the junior author has cast serious doubt upon the age determination of the "Oriskany" here. The paper may, however, be cited for structural data.

[5] Arthur B. Cleaves: The Geology of the New Bloomfield quadrangle, Pennsylvania; thesis presented as partial fulfillment of the requirements for the degree of Ph.D., on file, Harvard University Library.

PHYSIOGRAPHY

The region between Highspire and Half Falls Mountain demonstrates much of physiographic interest. Harrisburg is in the great Cumberland Valley which passes eastward into the Lehigh Valley and southwestward into the Shenandoah. The north side of the valley is floored by Upper Ordovician shale and is a region of low, rolling hills. The south side of the valley is a lowland of fertile, residual limestone soils bordered southward by hills of Triassic rocks. Bounding this valley along its northern border is a succession of more or less parallel, narrow Appalachian ridges and wider valleys. The principal ridges encountered from south to north are Kittatinny Mountain (also referred to as Blue, First, or North Mountain), Second Mountain, followed by Third Mountain which terminates east of the Susquehanna River, then Peters Mountain, and finally Half Falls Mountain. Peters and Second Mountains unite west of the Susquehanna in Cove Mountain. Smaller ridges are Little Mountain, Mahanoy Ridge, Pine Ridge and Dicks Ridge. Each ridge is supported by hard, resistant elements in the stratigraphic succession. Between the ridges are valleys cut in shale or weak sandstone.

The south-flowing Susquehanna and Juniata rivers are the master streams of the region. Their courses cross the several ridges in a series of water gaps unequalled elsewhere in the State, but the tributaries follow generally the bands of soft rock, seldom crossing even the minor ridges. Thus, a trellis-type of drainage has developed. Some of the streams show a remarkable tendency to meander. The distance from Carlisle to Harrisburg along the nearly straight highway is approximately 17 miles, but via the Conodoguinet Creek it is close to 36 miles.

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[6] Sixteenth International Geological Congress, Guidebook 10, Excursion B-1 (1933). The geologic section which accompanies this schedule is so inaccurate that it should be disregarded. At the time of the excursion, a mimeographed correction sheet was distributed to the participants.

[7] Bradford Willard: Field conference of Pennsylvania geologists, Science, vol. 77 (1933) pp. 629-630.

[8] Bradford Willard: A century of geologic surveys in Pennsylvania, Science, vol. 84 (1936) pp. 43-44.

A long discussion of the physiographic history of the region is omitted because we are primarily interested in the stratigraphy. Besides, there is so much that is controversial and unsettled about the local geomorphology, that one hesitates to offer any definite statements. Rather, for those particularly interested in this topic, reference should be made to the several recent publications upon the physiography of Pennsylvania, particularly the central part of the State.[9]

STRATIGRAPHIC SUCCESSION

The stratigraphic succession of the Harrisburg section embraces strata from the Lower Ordovician through the Triassic. Nearly all formations are well and completely exposed save for the Pennsylvanian system, most of which is absent, and the lack of any Permian. A description of each stratigraphic unit is presented. The general succession is simple. Because of the folding and dissection, the several units are exposed one after another in a succession of east-west bands which cross the principal valley nearly at right angles. Beginning south of Harrisburg, the Lower Ordovician (Canadian) limestones are succeeded northward successively by younger beds to the Pennsylvanian of Third Mountain Thence, north the succession is reversed. The higher ridges from south to north are supported in order by hard Silurian, Mississippian and Pennsylvanian sandstones and conglomerates. Devonian sandstones form lesser ridges. The valleys are underlain by less resistant units of the Ordovician, Silurian, Devonian and Mississippian. The Triassic forms hills south of the area.

ORDOVICIAN SYSTEM

Cambrian rocks are not exposed in this area. The Ordovician is the oldest system encountered. It consists of a thick limestone succession overlain by much shale. The limestones are not completely exposed, but the shale with its many variations may be seen at a number of vantage points. The following units are known:

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[9] George H. Ashley: Studies in Appalachian Mountain sculpture, Geol. Soc. Am., Bull., vol. 46 (1935) pp. 1395-1436.

George H. Ashley: Age of the Appalachian peneplains, Geol. Soc. Am., Bull., vol. 41 (1930) pp. 695-700.

George H. Ashley: The scenery of Pennsylvania, Pa. Topog. and Geol. Surv., Bull. G6 (1933).

M. R. Campbell: Chambersburg (Harrisburg) peneplain in the Piedmont of Maryland and Pennsylvania, Geol. Soc. Am., Bull., vol. 44 (1933) pp 553-573.

W. O. Hickok, 4th: Erosion surfaces in south-central Pennsylvania, Am. Jour. Sci., vol. 25 (1933) pp. 101-122.

Douglas Johnson: Stream sculpture on the Atlantic slope, New York (1931).

Frank Leverett: Glacial deposits outside the Wisconsin terminal moraine in Pennsylvania, Pa. Topog. and Geol. Surv., Bull. G7 (1934).

R. L. Miller: Martinsburg limestones in eastern Pennsylvania, Geol. Soc. Am., Bull., vol. 48 (1937) pp. 93-112.

K. Ver Steeg: Wind gaps and water gaps of the northern Appalachians, their character and significance, N. Y. Acad. Sci., anal. 32 (1930) pp. 87-220.

K. Ver Steeg: Warping of Appalachian peneplains, Jour. Geol., vol. 39 (1931) pp. 386-392.

Juniata red beds
"Oswego" sandstone
Martinsburg shale
Chambersburg limestone
Stones River limestone
Beekmantown limestone

Beekmantown limestone. The Beekmantown limestone consists of very massive, light to blue-gray, dolomitic limestone in places made impure by sandy or cherty beds. It has not been finally subdivided in the Susquehanna Valley. Faulting and folding and lack of complete exposures make a determination of thickness difficult, but it is probably of the order of 2000 feet. Fossils are very rare. A few fragments, probably of the gastropod *Ophileta,* have been reported from the region to the southeast.[10] The Beekmantown is exposed south of Harrisburg.

Stones River limestone. Overlying the Beekmantown limestone in areas west of the Susquehanna is the Stones River limestone, about 150 to 200 feet thick. It is relatively pure and less massive than the Beekmantown and carries distinctive fossils. The authors have not recognized it east of the river. The following fossils have been reported from the vicinity of Chambersburg:[11]

Girvanella cf. *G. chazyensis*
Stromatocerium sp. nov.
Tetradium syringoporoides; the single tubed form of this genus so characteristic of the Stones River.
Glyptocystites sp. undet.
Bryozoan, undetermined sp.
Lingulella ? belli (Billings)
Hebertella borealis
H. vulgaris
Dinorthis cf. *D. platys*
Strophomena aff. *S. charlottae*
Bucania sulcatina
Maclurea magna
Lophospira bicincta
Isochilina cf. *I. amiana*
Ampyx halli

Chambersburg limestone. The Ordovician limestone succession usually terminates above in platy limestone with thin, dark shale interbeds. The thickness is variable. East of Harrisburg city limits, the Chambersburg appears to be faulted out. West of the city, there are several hundred feet of platy beds which may belong to the Chambersburg, but are barren and probably belong to the basal Martinsburg. They occur again north of Wormleysburg. These are mapped (Plate 1) as Chambersburg and Stones River, but final identity has not been proved. True Chambersburg limestone is known a few miles west of the section. Because the Chambersburg intergrades with the overlying Martinsburg, it is difficult to delimit or distinguish the two at their contact. The Chambersburg or basal Martinsburg carries a graptolite fauna at Steelton, and west of the Susquehanna becomes quite fossiliferous.

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[10] G. W. Stose and A. I. Jonas: Geology and mineral resources of the Middletown quadrangle, Pennsylvania; U. S. Geol. Surv., Bull. 840 (1933).

[11] G. W. Stose: Description of the Mercersburg-Chambersburg district, Pennsylvania; U. S. Geol. Surv., atlas, folio 170 (1909).

A representative list from the upper part of the Chambersburg after Stose[12] follows:

Diplograptus sp. undet.
Lingula riciniformis?
Lingulops n. sp?
Conotreta rusti
Rafinesquina cf. *R. ulrichi*
Sinuites cancellatus
Scenella sp.
Bucania sp.
Cyclora minuta
C. parvula
C. cf. *C. hoffmani*
Microceras cf. *M. inornatum*
Coleolus cf. C. lowensis
Conularia quadrata?
Trocholites sp.
Orthoceras sp.
Caryocaris sp. undet.
Turrilepas sp. undet.
Primitia, 2 sp.
Ctenoholbina sp. undet.
Ampyx n. sp.
Trinucleus concentricus?
Harpina ottawaensis?
Triarthrus becki
T. fischeri
Calymene senaria?
Bumastus sp?
Bronteopsis? sp. undet.
Proetus latimarginatus
Cyphapsis matutina
Encrinurus sp. undet.

Martinsburg shale. The Ordovician limestone is overlain by the Martinsburg shale, one of the most controversial units in Pennsylvania. Below, it passes gradually over into the Chambersburg or older limestone or is faulted against even older beds. Above, it may intergrade with the "Oswego" sandstone, the Juniata red beds or be in unconformable contact with the Tuscarora sandstone. Its thickness is much discussed. At Harrisburg, 3000 feet is perhaps a fair estimate. A dearth of key beds and much folding inhibit close measurement. Usually called "shale", the Martinsburg is a variable lithologic group. Sandstone, often very heavy, occurs, but, owing to its calcareous cement, rarely produces topographic features. The principal body of these sandstones is here designated the West Fairview member for the village of that name near which these beds form a prominent hill. At least one pebbly unit has been found. It is named the Paxton Creek conglomerate from its outcrop near that stream in Harrisburg. It consists of ill-sorted, poorly-rounded, white quartz pebbles and shale chips in a muddy matrix. Very hard, in some places it is a true conglomerite.[13] Most of the Martinsburg is very dark-gray to olive-gray, buff, brown, or rusty weathering. Red beds also are known. Appearing first a few miles west of the Susquehanna, these red shales and sandstones thicken eastward. Interbedded with the clastic sediments, and often associated with the red beds are limestones. Generally, they are thin-bedded and platy, resembling the Chambersburg, but unlike it probably always are barren. Edgewise conglomerate or breccia, oölite and sandy layers also are present. So like the Chambersburg limestone are some of these, that they are distinguished with difficulty. It is not improbable that the underlying Chambersburg may be confused with these later beds if it happens to be up-faulted or up-folded high into the section.

Speaking broadly, the lithologic sequence of the Martinsburg observed between the Susquehanna and Schuylkill valleys is from top (north) to bottom (south) approximately as follows:

a. Shale, dark, with some sandstones; a few red beds, and thin limestones occur in the upper part plus a bed of siliceous shale about 10 feet thick. Fossils, including graptolites, are sparingly present. Lower down, red beds and platy limestone become a prominent feature.

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[12] G. W. Stose: Description of the Mercersburg-Chambersburg district, Pennsylvania; U. S. Geol. Surv., atlas, folio 170 (1909).

[13] Bradford Willard: Conglomerite, a new rock term, Science, vol. 71 (1930) p. 438.

b. Sandstones, massive, but usually weak (West Fairview member), locally conglomeratic (Paxton Creek conglomerate).

c. Shale and thin sandstones, dark colored and often much metamorphosed through pressure. The base changes into platy or shaly, buff or gray limestone as it passes over into the Chambersburg formation.

Fossils are rare in the Martinsburg, but in its higher parts an Eden fauna is widely distributed. The following were collected by the junior author west of the Susquehanna below Sterretts Gap:

Crinoidea, columnals
Pholidops cincinnatiensis
Plectorthis plicata
"Dalmanella" multisecta
Sowerbyella sericea
Leptaena gibbosa
Zygospira modesta
Bilobites?
Ctenodonta fillistriata
Cleidophorus planulatus
Modiolopsis?
Cryptolithus bellulus
Calymene sp. ind.
Triarthrus eatoni
T. sp. ind.

Stose[14] has listed several faunules from the Susquehanna Valley, as follows:

Eden fauna "next beneath the Juniata":

Aspidopera
Pholidops cincinnatiensis (middle Eden variety)
Lepidocoleus
Gastropod?
Sowerbyella n. sp. aff. *plicatella*
Cryptolithus bellulus
Cryptolithus sp. (middle Eden variety of *C. tesselatus*)

1,100 feet below the Juniata, "Normanskill fossils of Levis basin."

Didymograptus sagitticaulis
Dicellograptus sextans
Dicranograptus ramosus var.
Leptobolus walcotti
Climacograptus cf. *caudatus*
C. modestus
C. parvus
Diplograptus angustifolius

Next below Normanskill referred to "Deepkill fauna of Levis basin":

Goniograptus aff. *thoreaui* (n. sp.?)
G. perflexilis
Didymograptus extensus
D. bifidus (large form)
D. cf. *similis* and *nitidus*
D. cf. *indentus*
Tetragraptus quadribrachiatus
T. aff. *pendens* (probably n. sp.)
Phyllograptus angustifolius
P. cf. *ilicifolius*
P. cf. *anna*
Dichograptus (?)
Caryocaris curvilatus

"Oswego" sandstone. During the early months of 1937, highway construction opened new rock cuts exposing the top of the Ordovician and the basal Silurian north of Enola through the Water Gap. The section shows Martinsburg shale, fossiliferous to the topmost inch, which is succeeded by about 30 feet of gray sand-

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[14] G. W. Stose: Unconformity at the base of the Silurian in southeastern Pennsylvania, Geol. Soc. Am., Bull., vol. 41 (1930) pp. 629-658.

stone and conglomerate with ferruginous or rusty grains disseminated throughout. It is followed by the Juniata red beds. No fossils were found between the Martinsburg and the Juniata, but the lithology and stratigraphic position leave no reasonable doubt that the gray sandstone and conglomerate are the "Oswego." Disconformities may occur in this sequence, but there is no measurable angular discordance from the Martinsburg into the Tuscarora.

Juniata red beds. The Juniata red beds are by some considered basal Silurian; others place them at the top of the Ordovician. There is evidence for argument either way, but we place them in the Ordovician following the recent opinion of Frank M. Swartz.[15] Our own understanding of the whole Paleozoic succession agrees with this view. The Juniata intergrades with both overlying and underlying formations. Thicker to the west, it is represented on the west side of the Susquehanna Valley in new road cuts by at least 80 feet of red conglomerate, sandstone and shale. This exposure has not yet been fully studied as construction is not finished, but a fuller report is anticipated. A few beds of red shale and some coarse conglomerate east of the river may also belong to the Juniata.[16] A characteristic of this unit not noted in the several other red Paleozoic formations hereabout is the presence of numerous large, dark-red shale chips. Quartz pebbles also occur. The conglomeratic beds are weakly cemented. Fossils are unrecorded from the Juniata red beds in the State.

SILURIAN SYSTEM

The knowledge of the stratigraphy of the Silurian system in Pennsylvania has been refined, and its complex faunas unravelled and described in recent years, chiefly through the work of Frank M. Swartz. Professor Swartz recognizes the following Silurian succession in central Pennsylvania:[17]

- Cayugan series
    - Tonoloway limestone
    - Wills Creek shale
    - Bloomsburg red shale
- Niagaran series
    - McKenzie shale and limestone
    - Clinton group
        - Rochester shale
        - Keefer sandstone
        - Rose Hill shale
- Medinan series
    - Castenea sandstone
    - Tuscarora sandstone

The interpretation of the section on the Susquehanna is based for the most part on the work of Swartz and Swartz.[18] It is regrettable that many of the interesting divisions known in central Pennsylvania are obscured here because of the Middle and Upper

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[15] F. M. Swartz: Silurian sections near Mount Union, central Pennsylvania: Geol. Soc. Am., Bull. vol. 45 (1934) pp. 81-134.

[16] C. K. Swartz and F. M. Swartz: Early Silurian formations in southeastern Pennsylvania, Geol. Soc. Am., Bull., vol. 42 (1931) pp. 621-662.

[17] F. M. Swartz: idem, pp. 81-134.

[18] C. K. Swartz and F. M. Swartz: idem, pp. 621-662.

Silurian having gone over largely to continental red beds. The marine formations outcrop abundantly 20 to 30 miles northwest of Harrisburg in Perry County. Above Harrisburg the section is nevertheless interesting because it is fairly typical of the sort of Silurian found in eastern Pennsylvania.[19]

Tuscarora sandstone. The Tuscarora (or Shawangunk) heavy to medium-heavy bedded sandstone with conglomerates is the lowest Silurian formation in the Susquehanna Valley. The color is dark gray. The conglomerates carry mostly white quartz pebbles. Dark, shalier beds also appear. Westward the formation becomes whiter and purer; eastward it merges with the less pure, dirtier, Shawangunk of our eastern sections.[20] On the Susquehanna River there are about 275 feet of Tuscarora. This exceptional thinness is due to local faulting. The current assumption is that the Tuscarora or Shawangunk is the major Silurian ridge-forming element in eastern and central Pennsylvania, but in the Harrisburg section this is not the case. The crest of Kittatinny Mountain is supported mostly by red sandstones of the younger Rose Hill formation. The Tuscarora produces a bench along the southern flank, a feature readily observed when the leaves are off, particularly following a light snow-fall. The only recorded fossil from this formation near the Susquehanna is *Arthrophycus allegheniensis.*

Rose Hill formation. The Tuscarora sandstone grades upward into heavy red sandstones with a sprinkling of gray beds, the Rose Hill formation. These may be highly ferruginous, and sericitic mud chips are a diagnostic feature. This formation is the ridge-making element in Kittatinny Mountain above Harrisburg, where it is between 700 and 750 feet thick. The Rose Hill and later Silurian formations are barren in this section.

Rochester formation. Of the Rochester formation at Susquehanna Gap, only the Keefer sandstone is known. This is a heavy, gray sandstone 21 feet thick at the county line west of the river.

Bloomsburg red beds. The remaining Silurian north of Harrisburg is red shale and some red sandstones, the Bloomsburg. The top is hidden, but the juxtaposition of the Marcellus black shale is construed to indicate the absence of any later Silurian beds. Because of poor exposures, the total thickness of the Bloomsburg cannot be measured, but it is at least 500 feet. It is separated from the Keefer sandstone by a concealed interval which should include a portion of the Rochester and perhaps the McKenzie formation, units which aggregate some 250 feet in Perry County northwest of here.

DEVONIAN SYSTEM

By far the best displayed Paleozoic system in the lower Susquehanna and Juniata valleys is the Devonian. Only the Helderberg group below the New Scotland is partly concealed. The long succession embraces all of the overlying marine strata, terminating in the Catskill red beds. Contacts are exposed; minute details observable. Many of the units are highly fossiliferous, affording abundant data for correlation, relative age determinations and paleoecologic studies. The principal divisions of the Devonian are:

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[19] C. K. Swartz and F. M. Swartz: Age of the Shawangunk conglomerate of eastern New York, Am. Jour. Sci., vol. 20 (1930) pp. 467-474.

[20] Bradford Willard: The age and origin of the Shawangunk formation, Jour. Paleontology, vol. 1 (1928) p. 255-258.
C. K. Swartz and F. M. Swartz: idem, pp. 467-474.

- Upper Devonian
    - Catskill red beds including some Chemung
    - Portage group
- Middle Devonian
- Lower Devonian
    - Oriskany group
    - Helderberg group

LOWER DEVONIAN

HELDERBERG GROUP

Well-exposed in Perry County west of the Juniata-Susquehanna valleys, the Helderberg group is not completely seen in this section. Of the three formations of which it is composed, the New Scotland, Coeymans and Keyser, the Coeymans is unknown in the section. The highest, the New Scotland, has been recognized at only one place, the core of Half Falls Mountain where there is probably some Keyser as well. The exposed thickness is probably not over 12 or 15 feet. It is dark gray, shaly limestone weathering to an ocherous clay residue and contains a three foot bed of sandstone near the top. Helderberg fossils are not rare, but in the single exposure at Half Falls Mountain only *Spirifer macropleurus* and *Leptaena rhomboidalis* have been found.

ORISKANY GROUP

The Oriskany is here treated as a group composed of two distinct and mappable formations, the Ridgeley sandstone above and the Shriver "chert" below. Neither attains a great thickness in the Harrisburg section. A probable maximum of 50 feet would take in the group at its one exposure, Half Falls Mountain, where about 25 to 30 feet of its upper part show. The junior author spent the 1936 field season studying the Oriskany throughout Pennsylvania as an assignment with the State Survey, and his final determinations have not been completed nor ultimate conclusions drawn either as to the distribution of the formations or their enclosed faunas. That which is given regarding the group must therefore be looked upon as tentative, pending further corroboration from his researches.

Shriver formation. The lower Oriskany formation is the Shriver, characterized in the lower Juniata Valley by dark chert, which weathers rather easily; when deeply weathered it may be readily confused with fine sandstone. On the breaking down of the outcrop, the chert yields loose, angular fragments by which its presence is at once noted. The Shriver probably is not exposed in our section, but in central Perry County it reaches a thickness of

44½ feet. Fossils show affinities with the Helderberg, particularly the New Scotland formation, and in central Pennsylvania the Shriver is characterized by the following forms:

Zaphrentis sp.
Crinoidea, columnals
Edriocrinus sacculus
Polypora sp. ind.
Orbiculoidea ampla
Pholidops multilamellosa
Platyorthis (Dalmanella) planoconvexa
Rhipidomella musculosa
Leptaena rhomboidalis
Chonetes hudsonicus
Camarotoechia barrandii
Eatonia peculiaris
E. medialis
Rensselaeria ovoides
Atrypa reticularis
Spirifer tribulus
S. intermedius
Metaplasia plicata
Anoplotheca (Leptocoelia) flabellites
Meristella lata
Actinopteria sp. ind.
Platyceras gebhardi
Diaphorostoma desmatum
Tentaculites acus
T. elongatus
Dalmanites, several species
Ostracoda, numerous species

Ridgeley formation. The Ridgeley sandstone is the upper Oriskany formation and is well exposed at Half Falls Mountain. It consists of fine to coarse sand, well sorted and rounded, yellow to nearly white. The upper part is a conglomerate with phenoclasts one-sixteenth to one-eighth inch in diameter. Because of the variable character of the cement, it is locally a secondary ridge maker, but as often breaks down to loose sand. Fossils are plentiful. A representative fauna from central Pennsylvania includes the following:

Zaphrentis sp.
Edriocrinus sacculus
Leptaena rhomboidalis
Hipparionyx proximus
Eatonia peculiaris
Rensselaeria marylandica
R. (Beachia) suessana
Spirifer intermedius
S. murchisoni
S. arenosus
Cyrtina rostrata
Anoplotheca (Leptocoelia) flabellites
Meristella lata
Orthonychia tortuosum
Platyceras subconicum
Diaphorostoma desmatum
Homalonotus sp. ind.
Dalmanites sp. ind.

MIDDLE DEVONIAN

The term Hamilton group has been used to include all of the Middle Devonian, that is, from the top of the Oriskany to the base of the Portage. This usage was recently recommended by the senior author following his studies of the Onondaga formation.[21] However, the advisability of such use is still questionable. Many of the Middle Devonian subdivisions occur in the Susquehanna Valley. Mahantango is reserved for the highest.[22] Hamilton includes all between the Onondaga and the Tully.

Onondaga formation. The Onondaga formation in the Harrisburg section is visible at Half Falls Mountain only as about 50 feet of black limestone quarried on the south flank. Throughout much of central Pennsylvania, the Onondaga consists of two members, limestone above and shale below, both weathering deeply to an olive-drab, punky residue. Fossils, usually plentiful,[23] are scarce at Half Falls Mountain. A few crinoid columnals, one or two undeterminable corals and the ubiquitous *Anoplotheca acutiplicata* have been found there. The shale member is concealed or absent at Half Falls, but is present in most adjacent sections. In Pennsylvania the basal contact of the Onondaga shale member with the Oriskany is a disconformity. The limestone is separated from the overlying Marcellus black shale by a local disconformity in the Harrisburg section and near-by parts of the Susquehanna and Juniata valleys. This is marked usually by a few inches of sandstone. In most parts of the State, however, the Onondaga and Marcellus are transitional. This transition and the close faunal affinities of the Onondaga to the succeeding Middle Devonian were Willard's reasons for placing it in the Hamilton group. Nothing lithologically closely resembling the Esopus of our eastern region has been found in the Juniata Valley, but the lower shale member of the Onondaga is probably the correlate of the Esopus.

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[21] Bradford Willard: The Onondaga formation in Pennsylvania, Jour. Geol., vol. 44 (1936) pp. 578-603.

[22] Bradford Willard: Hamilton correlations; Am. Jour. Sci., 4th ser., vol. 33, 1937, pp. 264-278.
Devonian nomenclature in Pennsylvania; pr. Pa. Acad. Sci., vol. 11, pp. 26-34, 1937.

Marcellus formation. Above the Onondaga and transitional therewith save for local disconformity, lies the Marcellus black shale. In Juniata County Willard[24] split this formation into four members:

Mahanoy black shale
Mexico platy sandstone
Turkey Ridge massive sandstone
Shamokin black shale

The highest is partly exposed in the southernmost Rockville quarry at Little Mountain as 50 feet of black, fissile shale. Black Marcellus shale is also seen in the south flank of Half Falls Mountain overlying the Onondaga. The sandstone members are not recognized in this region, and probably never extended so far south. Marcellus fossils are very scarce in central Pennsylvania, but *Styliolina fissurella* and *Liorhynchus limitare* can usually be discovered.

Mahantango formation. In eastern Pennsylvania, the post-Marcellus portion of the Middle Devonian, the Hamilton, *senso-stricto,* is divisible into three parts:[25]

Moscow formation
Ludlowville formation
Skaneateles formation

Lesser divisions are known, but we need mention only a coral reef coming at the base of the Ludlowville and correlated with the Centerfield limestone of New York.[26] In central Pennsylvania the three formations become lithologically obscure and even the faunal distinctions are not always clear. Because of this difficulty, the inclusive name Mahantango formation was introduced[27] to embrace the Middle Devonian above the Marcellus. The Mahantango formation has a maximum thickness of 1000 to 1200 feet and is usually quite fossiliferous. Local divisions are recognized in central Pennsylvania.

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[23] E. M. Kindle: The Onondaga fauna of the Allegheny region, U. S. Geol. Surv., Bull. 508 (1912).

[24] Bradford Willard: Hamilton group of central Pennsylvania, Geol. Soc. Am., Bull., vol. 46 (1935) pp. 195-224.

[25] Bradford Willard and Arthur B. Cleaves: Hamilton group of eastern Pennsylvania, Geol. Soc. Am., Bull., vol. 44 (1933) pp. 757-782.

[26] Bradford Willard: A Hamilton coral reef in Pennsylvania, Pa. Acad. Sci., pr., vol. 10 (1936) pp. 30-36. Since the writers studied the Rockville section, quarry operations have largely destroyed the exposures of these beds so that it is now very difficult to see them.

Rockville sandstone. In the southernmost quarry at Rockville in the base of the Mahantango formation and just above the Marcellus occurs a very hard, dark gray, four-foot sandstone. This is the Rockville member which extends westward into Perry County marking the base of the Mahantango formation which here carries some shale. The Rockville member is early Skaneateles in age and carries a meager fauna:

Leptostrophia perplana
Chonetes coronatus
Rhipidomella sp.
Tropidoleptus carinatus
Spirifer granulosus

Montebello sandstone. The Montebello sandstone ranges from 800 to 1000 feet thick in Dauphin and Perry counties to zero in northeastern Lebanon, northern Northumberland and western Juniata counties.[28] It is locally the most prominent feature of the Mahantango formation and of the whole Middle Devonian, but is displaced by shale within a few miles of its point of greatest development, the Harrisburg section. It is supposed to represent the delta of a river which debouched northward near Rockville.[29] Faunally, it can be divided. Near the base of the upper third, at Rockville, there is a pebbly sandstone which, among other fossils, carries corals. This is supposed to represent the aforementioned coral reef of eastern Pennsylvania which is correlated with the Centerfield limestone of New York.[30] If this correlation be true, the next overlying beds are of Ludlowville age. Such a correlation may be suggested by the following fauna from the higher portion of the Montebello sandstone:

Corals, undet.
Crinoidea, columnals
Hederella sp.
Fenestella sp.
Bryozoa, undet.
Leptostrophia perplana
Stropheodonta inequistriata
Schuchertella variabilis
Chonetes mucronatus
C. coronatus
Productella spinulicosta
Rhipidomella leucosia
Camarotoechia congregata
C. prolifica
C. cf. *prolifica*
Tropidoleptus carinatus
Atrypa reticularis
Newberria sp. nov.
Spirifer mucronatus
S. granulosus
S. angustus
S. cf. *angustus*
S. sculptilis
S. audaculus
Vitulina pustulosa
Athyris spiriferoides
Nuculites oblongatus
N. sp.

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[27] Bradford Willard: Hamilton group of central Pennsylvania, Geol. Soc. Am., Bull., vol. 46 (1935) p. 195-224.
Bradford Willard: Hamilton group along the Allegheny Front, Pennsylvania, Geol. Soc. Am., Bull., vol. 46 (1935) pp. 1275-1290.

[28] E. W. Claypole: A preliminary report on the palaeontology of Perry County, Pa. Second Geol. Surv., vol. F2 (1885).
Bradford Willard and Arthur B. Cleaves: Hamilton group of eastern Pennsylvania, Geol. Soc. Am., Bull., vol. 44 (1933) pp. 757-782.

[29] Bradford Willard: Hamilton group of central Pennsylvania, Geol. Soc. Am., Bull., vol. 46 (1935) pp. 195-224.

[30] Bradford Willard: A Hamilton coral reef in Pennsylvania, Pa. Acad. Sci., pr. vol. 10 (1936) pp. 30-36.

Pterinea flabellum
Aviculopecten cf. *princeps*
A. fasciculatus
Pleurotomaria sulcomarginata
P. sp.
Gastropod undet.
Trilobite, undet.
Elymocaris sp. nov.
Taonurus sp.
Plant fragments

That lower Montebello sandstone is Skaneateles in age, is suggested by the following list of its fossils:

Zaphrentis prolifica (?)
Crinoidea, columnals
Bryozoa, undet.
Chonetes coronatus
Rhipidomella vanuxemi
R. sp.
Camarotoechia prolifica
Tropidoleptus carinatus
Atrypa reticularis
Spirifer granulosus
S. audaculus
Paracyclas lirata
Bellerophon sp.
Tentaculites bellulus
Orthoceras sp.
Bactrites aciculus
Plantae

The Moscow is concealed at Rockville, but in other localities where present, intergrades with the top of the Montebello. The Montebello sandstone may be seen at several near-by places. Besides at Rockville, it is well exposed across the river below Marysville and at Half Falls Mountain and Dicks Ridge.

Moscow formation. In the northern part of the section above and perhaps including the top of the thinning Montebello sandstone, and below the Portage is the Moscow formation. It consists of 50 or more feet, mostly of dark gray, non-fissile shale with an abundance of fossils and a zone of *Vitulina pustulosa* at or near its top. The formation has yielded:

Streptelasma rectum
Cladochonus sp.
Ceratopora jacksoni
Crinoidea, columnals
Bryozoa, undet.
Craniella hamiltoniae
Chonetes vicinus
C. lepidus
Rhipidomella leucosia
Liorhynchus laura
Atrypa reticularis
Spirifer sculptilis
S. mucronatus
S. sp.
Elytha fimbriata
Ambocoelia umbonata
Vitulina pustulosa
Palaeoneilo sp.
Platyceras erectum
Diphorostoma lineatum
Styliolina fissurella
Phacops rana
Dalmanites boothi
Bollia cf. *obesa*

UPPER DEVONIAN

PORTAGE GROUP

The Upper Devonian begins with the lowest beds of the Portage group which in the Juniata Valley are represented by a remnant of the Tully. This rests disconformably upon the highest Hamilton, the Moscow shale, with its *Vitulina* zone. The top of the Portage group lies approximately at the base of the Catskill red beds, of early Chemung age. Several divisions of the Portage are recognized in Pennsylvania, and all occur in the Harrisburg section.[31]

- Fort Littleton formation
    - Parkhead sandstone
    - Trimmers Rock sandstone
    - Losh Run shale
    - Brallier sandstone and shale
    - Harrell gray shale
- Rush formation
    - Burket black shale
    - Tully shale and limestone

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[31] Bradford Willard: Portage group in Pennsylvania, Geol. Soc. Am., Bull., vol. 46 (1935) pp. 1195-1218.

The formational terms, Fort Littleton and Rush, may be disregarded in the following discussion, for they have little or no significance in the Harrisburg section. Emphasis must be placed upon the several members.

Important changes among the members of the Portage group are known from the Allegheny Front through our area into eastern Pennsylvania. On the west they are practically all shale, save for the Tully limestone of varying thickness, and the group is dominated by the thick Brallier shale. From the Susquehanna Valley east the dominant element of the Portage group is the Trimmers Rock sandstone which has largely displaced the Brallier shale. The thin basal Brallier itself and the underlying Harrell become sandy. East of the Susquehanna, all of the Portage above the Burket is assignable to the Trimmers Rock both faunally and lithologically, since that member (strictly speaking a facies development) displaces the rest downward. Tully is little known east of the Susquehanna, and presumably is displaced by Burket black shale.

Tully shale and limestone. Only recently has the Tully been recognized in the lower Juniata Valley, although known over a large area in central and south-central Pennsylvania.[32] The authors had concluded independently that there was no Tully in Perry County and that the Burket rested directly upon the Hamilton.[33] Recently, Dr. G. A. Cooper in company with the senior author identified Tully fossils from the section along the Juniata above Amity Hall. There it consists of dark, limy shale bearing limestone nodules. It is about ten feet thick and its fauna includes *Hypothyris venustula, Echinocoelia ambocoelioides* and *Emanuella pennsylvanica,* all abundant species in the Tully of Pennsylvania. The beds rest discomformably upon the Hamilton, but grade into the overlying Burket shale. Subsequently two or three additional localities for Tully, chiefly shale, were found in nearby parts of Perry County.

Burket shale. Along the highway north from Amity Hall above the Tully is nearly 200 feet of the Burket black shale. This was formerly called the Genesee, and probably does equal the Geneseo of New York State.[34] This correlation is not fully established, and the local name proposed by Butts is retained in preference.[35] The Burket is a black, fissile shale, nearly barren, save for many specimens of *Styliolina fissurella* and *Buchiola retrostriata* and, rarely, a few other small pelecypods. The Burket intergrades with the Tully, but is faunally and lithologically quite distinct from the following member, the Harrell.

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[32] Bradford Willard: A Tully limestone outcrop in Pennsylvania, Pa. Acad. Sci., pr., vol. 8 (1934) pp. 57-62.
Bradford Willard: *Hypothyridina venustula* (Hall) in Pennsylvania. Am. Jour. Sci., vol. 29 (1935) pp. 93-97.
Bradford Willard: The Tully limestone and fauna in Pennsylvania, *in press* (1937). See abstract of this paper, Geol. Soc. Am., pr. 1935 meeting.

[33] Bradford Willard: Middle-Upper Devonian contact in Pennsylvania, Pa. Acad. Sci., pr., vol. 9 (1935) pp. 39-44.

[34] Bradford Willard: Portage group in Pennsylvania, Geol. Soc., Am., Bull., vol. 46 (1935) p. 1217.

[35] Charles Butts: Geologic section in Blair and Huntingdon counties, Pennsylvania: Am. Jour. Sci., 4th ser., vol. 46 (1918) pp. 523-537.

Harrell shale. The Burket is succeeded directly without noticeable transition by the Harrell shale, a persistent member west from the Juniata Valley. It is a soft, dark gray shale. Thin sandstones become fairly prominent in its upper part on the Juniata where a thickness of approximately 125 feet is assigned this member. The precise thickness cannot be given because of its transitional relationship with the overlying Brallier. The Harrell carries a Naples fauna, including:

Lunulicardium encrinitum
Pterochaenia sinuosa
P. fragilis
Buchiola retrostriata
Paracardium doris
Styliolina fissurella
Coleolus sp.
Hyolithes sp.
Bactrites sp.
Manticoceras patersoni
Probeloceras lutheri

Brallier shale. In Blair, Bedford, Huntingdon and adjacent counties, the Harrell shale is overlain by 1500 to 2000 feet of the Brallier greenish shale. In the Juniata Valley above and interfingering with the Harrell is about 220 feet of sandy beds assignable to the Brallier. Most of the local exposures of the member are highly contorted and broken, so that the thickness is determined only approximately. Characteristic greenish shale which breaks on very smooth bedding surfaces is present amidst the sands. Fossils are rare. The sandy beds carry an occasional Ithaca species, and the shales, at least in the lower part, have a few Naples forms. The trail, *Pteridichnites biserialis,* distinctive of the more western Brallier, has not been surely identified in this section. The Brallier is sharply separated from the Trimmers Rock sandstone by the Losh Run shale.

Losh Run shale. Well exposed above the Brallier shale south of Half Falls Mountain along U. S. Route 22 is 10 feet of Losh Run shale whose type locality is across the river from here. It is a brown, weak rock which breaks into irregular chunks without regard to bedding or joints. In it are many *Elytha (Reticularia) laevis* and little else save *Cladochonus humilis* and fragments of crinoid stems. It is the "*Cladochonus-Reticularia* zone" of central Pennsylvania and is a splendid datum for the region. It is correlated with a similar zone known in Maryland.[36]

Trimmers Rock sandstone. The dominant Portage element in the Susquehanna-Juniata valleys is a 1600-foot sandstone, the Trimmers Rock, whose type locality is but a few miles beyond the northern limit of the Harrisburg section.[37] It has been called Ithaca, but that name is inapplicable. Our best exposure is a high, artificial cliff along U. S. Route 22, north of Amity Hall, where it consists of flaggy to massive, gray sandstone which weathers brownish and has minor shale interbeds. Storm-roller zones are present. Although the list of fossils is diversified, the identifiable remains are not plentiful on the highway. They occur in thin bands of comminuted shells, the heavier sandstones being nearly barren. Better collecting is to be had along the railroad south of Marysville west of the Susquehanna where the Trimmers Rock, though thinner and less well exposed, is more weathered. The following is a representative, composit list of its fossils from the general region of our section:

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[36] C. S. Prosser, E. M. Kindle, C. K. Swartz: Middle and Upper Devonian, Md. Geol. Surv. (1913).

[37] Bradford Willard: Portage group in Pennsylvania, Geol. Soc. Am., Bull., vol. 46 (1935) p. 1201.

Coral, indet.
Crinoidea, columnals
Petalotrypa cf. *compressa*
Fenestella sp.
Semicoscinium sp.
Bryozoa, indet.
Stropheodonta cf. *demissa*
S. maynardi
Leptostrophia perplana var. *nervosa*
Schuchertella sp. nov.
Chonetes lepidiformis
Productella lachrymosa
P. sp.
Rhipidomella vanuxemi
R. sp.
Schizophoria striatula
Camarotoechia congregata
Liorhynchus globuliforme
L. cf. *quadricostatum*
Tropidoleptus carinatus
Atrypa reticularis
Spirifer mesastrialis
S. mucronatus var. *posterus*
S. mesacostalis
Athyris spiriferoides
Brachiopod, indet.
Grammysia communis
G. sp.
Nucula corbuliformis
N. sp.
Nuculites cf. *oblongatus*
Palaeoneilo brevis
Pterinea chemungensis
P. prora
Ectodesma birostratum
E. sp.
Liopteria sp.
Pelecyopod, indet.
Bellerophon clarki
B. nactoides
Bucanopsis maera
Diaphorostoma lineatum
Tentaculites descissus
T. spiculus

Parkhead sandstone. The top of the Portage in Maryland is occupied by a heavy sandstone, the Parkhead.[38] This has been recognized in south-central Pennsylvania,[39] but its identity in the Harrisburg section is not fully established. Along the east side of the Juniata above Amity Hall between the Trimmers Rock sandstone and the lowest Catskill red beds is 50 feet or more of reddish-brown to chocolate-hued, moderately heavy sandstone. Its Portage fauna contains elements which suggest that it may be correlated with the Parkhead:

Rhipidomella vanuxemi
Camarotoechia congregata var. *parkheadensis*
Tropidoleptus carinatus
Spirifer mesacostalis
S. marcyi var. *superstes*

Chemung formation. In the Harrisburg area we cannot assign a definite group of beds to the Chemung formation. The lowest Catskill red beds rest directly upon the highest Portage strata in the Juniata Valley and perhaps come even lower on the Susquehanna below Marysville. Chemung fossils occur among these lowest red sandstones and shales[40] along the Juniata south of Half Falls Mountain in interbedded greenish shales, each an inch or two thick, which carry a sparse marine fauna including *Spirifer disjunctus.* About 500 feet above the base of the red beds in Perry County, but not seen in our section, the white Kings Mill sandstone carries the same *Spirifer* and an abundance of *Schizophoria rhombeus. Spirifer disjunctus* recurs a few hundred feet higher in central Perry County in the Dellville shale. The region evidently lay at the eastern extremity of distribution of marine Chemung sediments at the beginning of that epoch and was an area in which continental sediments dominated.[41]

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[38] C. S. Prosser, E. M. Kindle, C. K. Swartz: Middle and Upper Devonian, Md. Geol. Surv. (1913).

[39] G. W. Stose and C. K. Swartz: Description of the Pawpaw and Hancock quadrangles Md., W. Va., and Pa., U. S. Geol. Surv. atlas, folio 179 (1912).

[40] E. W. Claypole: A preliminary report on the palaeontology of Perry County, Pa. Second Geol. Surv., vol. F2 (1885).

Bradford Willard: Chemung of southwestern Pennsylvania, Pa. Acad. Sci., pr. vol. 7 (1933) pp. 148-159. Subsequent to the publication of the paper, additional information has somewhat changed our understanding of the Devonian stratigraphy of southwestern Pennsylvania.

Bradford Willard: "Catskill" sedimentation in Pennsylvania, Geol. Soc. Am., Bull., vol. 44 (1933) pp. 495-516.

Catskill red beds. In northeastern Pennsylvania the senior author has recognized and correlated several divisions of the continental Catskill facies.[42] Briefly the succession is:

Marine equivalent	*Catskill continental units*
Upper Conewango	Elk Mountain
Lower Conewango	Upper Cherry Ridge
Conneaut	Lower Cherry Ridge
Upper Canadaway	Honesdale
Middle Canadaway	Damascus
Lower Canadaway	Shohola (Paupack)
Chemung	Shohola (Berryville)
Upper Portage	Delaware River

Some of these divisions extend into the valley of the Susquehanna. In our section the Catskill red beds make up all of the post-Portage Devonian save for the slight incursions of marine Chemung just noted, and continue to the base of the Pocono sandstones. The Catskill is not less than 4500 feet thick. As the rocks are folded in the best exposures, which are along the lower Juniata Valley, the thickness is obtained with difficulty. These alternate red sandstones and shales have, besides the marine incursions mentioned, at least two recognizable units of correlative value. In an abandoned quarry east of the railroad at Heckton is seen the lower of these, some 60 feet of hard, greenish sandstone with plant fragments. It forms a low, subsidiary ridge along the south flank of Second Mountain. This is a persistent bed correlated with the Honesdale sandstone of northeastern Pennsylvania. Its age, as shown above, is Canadaway, that is, post-Chemung. Somewhat above the Honesdale is a band of varying thickness of hard, red sandstones and conglomerate which is believed to be the westward equivalent of the Pimple Hill conglomerate, a prominent band in the lower Cherry Ridge on the Pocono Plateau. As such, it is Conneaut in age. The top of the Catskill in this region is not at once apparent, but from observations elsewhere in the State, the line is drawn at the base of the heavy gray sandstone, the Second Mountain member, of the Pocono.

MISSISSIPPIAN SYSTEM

The Mississippian formations exposed in the lower Susquehanna Valley are all of continental origin so far as proved. Their identifiable fossils are plants collected from the Pocono formation.

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[41] Bradford Willard: Early Chemung shore line in Pennsylvania, Geol. Soc. Am., Bull., vol. 45 (1934) pp. 897-908.

[42] Bradford Willard: Continental Upper Devonian of northeastern Pennsylvania, Geol. Soc. Am., Bull., vol. 47 (1936) pp. 565-608.

Long distance correlations establish the relationships of the Mississippian formations here.

Pocono formation. The Lower Mississippian is represented by the Pocono formation. Sixteen hundred feet of sandstones and pebble beds is exposed in sections in the water gaps at Second and Peters mountains.* Three members, mutually intergrading, but nevertheless distinct, and of about equal thicknesses are recognized:

Cove Mountain member
Peters Mountain member
Second Mountain member

The trifid character of the Pocono is quite evident as seen along the Susquehanna, and the recognition of the three-fold succession is a valuable means of correlation in eastern Pennsylvania.[43] The lowest, the *Second Mountain member,* is massive, gray sandstone and pebble beds which rest on the Catskill red beds of the Upper Devonian. It has been referred to as the "Berea," but, because there seems little ground for correlating it with the Berea of northwestern Pennsylvania, the name Second Mountain is proposed after its excellent exposure at Second Mountain on the railroad north of Heckton. The middle division, the *Peters Mountain member,* was named for exposures at Peters Mountain east of the Susquehanna at Clarks Ferry.[44] It consists of platy, gray sandstone with few pebble beds. In this it differs from the subjacent and superjacent members. The *Cove Mountain member* is a name proposed for the upper division of the Pocono. Its type locality is at Cove Mountain south of Duncannon where these beds show in highway cuts. It may equal the Burgoon of more western sections, with which it has been correlated and by which name it has sometimes been called. Doubt of precise correlation warrants the introduction of this new name. The Cove Mountain member is lithologically nearly the counterpart of the Second Mountain member, gray sandstones and pebble beds, but is distinguished by the presence of several beds of coal. At least one of these attains a thickness of four feet where it has been unsuccessfully mined on Peters Mountain about five miles east of the Susquehanna River. The Cove Mountain member passes over fairly abruptly into the succeeding Mauch Chunk red beds. Plant fossils, pronounced Mississippian by David White,[45] have been found, chiefly in this upper member associated with the coals.

Mauch Chunk red beds. The Upper Mississippian is represented in the Susquehanna Valley by between 2000 and 3000 feet of red beds. Considerable local folding prevents close thickness measurement. It is a monotonous succession of red sandstone and shale, apparently devoid of significant organic remains or key beds, but there is evidence of the existence of a coarse conglomerate at the top below the Pottsville. Many exposures are seen north of

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*This figure excludes the "transitional beds" placed by some in the Pocono, but here relegated to the Catskill.

[43] Bradford Willard: Continental Upper Devonian of northeastern Pennsylvania, Geol. Soc. Am., Bull., vol. 47 (1936) pp. 565-608.

[44] Bradford Willard: The Mississippian system in Pennsylvania. Report prepared for the National Research Council (1935) and pending publication.

[45] Personal communication to the senior author.

Dauphin and across the Susquehanna in the triangular valley within Cove Mountain. The Mauch Chunk passes down into the Pocono by only a short transition. It is overlain by the Pottsville conglomerate in Third Mountain, but elsewhere in this region the Pennsylvanian is missing, and the top has been eroded. It should be observed that neither the Loyalhanna formation nor the Greenbriar limestone of western Pennsylvania has been identified in the Susquehanna Valley.

PENNSYLVANIAN SYSTEM

Only a few feet of the lowest Pennsylvanian are found in the Harrisburg section. The western limit of the Southern Anthracite Field dies out along the crest of Third Mountain above Dauphin. Nothing being represented between the early Pennsylvanian and the Triassic, a great break in the succession in this area follows the fragment of "Coal Measures" present.

Pottsville conglomerate. The Pennsylvanian is represented, as noted, by its basal portion only, a few feet of the lower part of the Pottsville conglomerate. This is a coarse, hard, white-quartz-pebble conglomerate. It forms the sharp crest of Third Mountain northeast of Dauphin where it is exposed in the limbs of an overturned syncline. Among the pebble beds are occasional impressions of tree trunks; and, judging from ancient prospect pits, a little coal also is present.

TRIASSIC SYSTEM

The Triassic is the youngest system of consolidated rock to be seen near Harrisburg. The southern end of the section attains the northern edge of the wide belt of Triassic continental strata which crosses Pennsylvania in a southwesterly direction from the Delaware River to Gettysburg.[46] Since only a little of these sediments is to be seen, a long discussion is unnecessary. Triassic igneous rocks intrude the Harrisburg section.

Newark group. South of Harrisburg along the highway below Steelton cuts expose red sandstone, shale and conglomerate assigned to the Newark group. These are faulted down against the Beekmantown limestone to the north, but the contact is not exposed. The thickness of the group is questionable. It probably is of the order of ten to fifteen thousand feet. No fossils have been found at the Steelton section, but plant remains are known from elsewhere, and, near Yocumtown, to the south across the river, tracks of two species of dinosaur have been collected. Near York Springs tracks of three species have been found recently.[47] Triassic basic igneous rocks occur. Occasionally thin dikes of very great linear extent run off from the main bodies into adjoining territory. One (actually there are two or a single one that occasionally splits) crosses the section above Amity Hall. It has been identified intermittently southward across Perry and Cumberland counties. The dike may be recognized by the yellow-brown, rusty soil which it produces. Thin zones of baked sediments form the contacts. On the Juniata the dike is about 25 feet thick. A second one a few inches thick also has been found there.

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[46] G. W. Stose and A. I. Jonas: Geology and mineral resources of the Middletown quadrangle, Pennsylvania; U. S. Geol. Surv., Bull. 840 (1933).

[47] Wm. O. Hickok, 4th and Bradford Willard: Dinosaur foot-tracks near Yocumtown, York County, Pennsylvania, Pa. Acad. Sci., pr., vol. 7 (1933) pp. 55-58.

Arthur B. Cleaves: Quarry gives up Dinosaur footprints after millions of years, Monthly Bull., Dept. Int. Aff., Commonwealth of Pennsylvania, vol. 4, No. 3, (1937) pp. 12-15.

PLEISTOCENE AND RECENT

The area under discussion is 30 miles south of the known limit of Pleistocene glaciation, and outwash gravels, terraces and like phenomena are to be seen here.[48] Harrisburg is largely built upon outwash gravels, but good exposures are rare within the city limits. The best opportunity to see these is in large gravel pits south of Highspire. High terrace gravels may be observed on the cut-off of U. S. Route 22 in the northeastern part of Harrisburg adjacent to the State Hospital where the deposit rests on an exposure of Martinsburg shale.

STRUCTURES

The section along the Susquehanna and Juniata valleys offers some fine examples of structures characteristic of this part of Pennsylvania. The Ordovician limestones are folded and faulted. This may be observed along U. S. Route 230 south of Harrisburg, particularly in the Bethlehem Mines Corporation quarry at Steelton.[49] The Martinsburg shale is closely folded with occasional faults, but exposures are usually such that the structure can be appreciated only after careful study.[50] It is, nevertheless, quite apparent that there is a general tendency to overturn north. This overturning is carried on into the younger formations. The Silurian units in Kittatinny Mountain dip steeply south because of northward overturning. The same is true of the Montebello sandstone in Little Mountain and the Pocono in Second Mountain. The Pottsville at the crest of Third Mountain is exposed in the axis of a syncline overturned north. This is the axis of the large syncline whose limbs are marked by Second and Peters mountains, which, bending toward each other to the west, unite in Cove Mountain. In the enclosed valley the Mauch Chunk shales and sandstones have been variously distorted. The rocks in Peters Mountain dip normally south. Continuing up the Juniata further structures are observable.[51]

The Catskill red beds north of Amity Hall are thrown into a long succession of small, relatively open folds beautifully exposed along the highway and on the railroad which follows the opposite bank of the Juniata. As the section rises northward and exposes older units, the Trimmers Rock sandstone emerges. This resistant element has suffered little folding, but the underlying Portage shales, particularly the Brallier, despite its sandy constituents, have been crushed, close-folded, broken and distorted to the remarkable degree observable along U. S. Route 22. Immediately south of Half Falls Mountain, the Hamilton rises to the surface again, having passed completely under the great Cove Mountain syncline. The massive Montebello sandstone makes a small anticline, dips down again, and then rises steadily to form Dicks Ridge south of Half Falls Mountain. This is a north-facing fault block thrust from the south along the Perry County fault. The sandstone again rises in Half Falls Mountain, an anticline with two minor faults causing small displacements near the crest and parallel to the axial plane.

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[48] Frank Leverett: Glacial deposits outside the Wisconsin terminal moraine in Pennsylvania, Pa. Topog. and Geol. Surv., Bull. G7 (1934).

[49] B. L. Miller: Limestones of Pennsylvania, Pa. Topog. and Geol. Surv., Bull. M20 (1933).

[50] G. W. Stose: Unconformity at the base of the Silurian in southeastern Pennsylvania, Geol. Soc. Am., Bull., vol. 41 (1930) pp. 629-658.

[51] Arthur B. Cleaves: Structural geology of the New Bloomfield quadrangle, Pennsylvania, Pa. Acad. Sci., pr., vol. 9 (1935) pp. 141-146.

Mention has been made of a possible fault between Kittatinny and Little Mountains. In the narrow valley between them at Rockville, the Bloomsburg red shale is exposed to the south and the upper Marcellus black shale to the north, the two separated by only a few feet of concealed interval. Evidently most or all of the highest Silurian (Wills Creek and Tonoloway) and the Helderberg, Oriskany, Onondaga and most of the Marcellus are absent. Across the river similar relations may be observed. The assumption is that faulting cut out the higher Silurian and Lower Devonian, unless, indeed, these units were never deposited here.

Several small, local faults are to be seen in the basal Silurian along the railroad at Rockville. Here the coarse conglomerate which perhaps is of Juniata age, is faulted against the Tuscarora. The Tuscarora itself is sliced by north-dipping fault surfaces which condition, it is believed, is the reason for its abnormal thinness here. A fault between the Triassic and Ordovician certainly exists south of Harrisburg, but is concealed. East of the city at Paxtang in the valley of Spring Creek north of Derry Street (U. S. Route 422), the Martinsburg shale is seen faulted against the Beekmantown limestone. The new highway cuts along the west side of the river at the Water Gap below Marysville show the conformable relations of the Upper Ordovician and Lower Silurian formations. This is significant considering their varying degrees of disconformity to the east.

DETAILED ITINERARY

The following itinerary is intended as a guide to the section along the Susquehanna and Juniata valleys. It starts at Harrisburg, runs north along the east side of the Susquehanna River to Clarks Ferry, crosses over to the west side at the confluence with the Juniata River and follows the east bank of that stream to Half Falls Mountain. Here, an about face is made, returning to Clarks Ferry, but at that point, the route is traced along the west bank of the Susquehanna to a point opposite Harrisburg. Crossing the river there, the course is laid down the east shore to a point immediately south of Highspire.

All distances given are measured from the zero mile post behind the State Capitol at Harrisburg.

The entire area is included in the Harrisburg, New Bloomfield, and New Cumberland topographic sheets. The Loysville sheet is useful if the supplementary side trips are taken into Perry County. A reliable highway map will be found helpful. The State and county geologic maps should be consulted.[52]

Miles	
0.0	Start at zero mile post behind State Capitol, Harrisburg. Follow street car track north on Commonwealth Avenue, at the rear of the Capitol.
0.1	Left into North Street, following U. S. Route 22.
0.5	Right at end of North Street into Front Street. Proceed north along the river on U. S. Route 22 crossing river gravels, etc., which underlie the northern end of the city.
4.4	View of Susquehanna Gap in Kittatinny (Blue, First or North) Mountain. On the slope east of the gap are patches of Tuscarora gray sandstone and conglomerate about half way to the top. These carry *Arthrophycus*. Note that, not the Lower Silurian gray sandstone, but the Middle Silurian red sandstone forms the mountain crest. The red-gray contact is at the top of a bench near the crest, observable west of the river when the leaves are off. Across the river also is seen Little Mountain, its face scarred by a large, abandoned quarry at the west end of the stone arch bridge. The horizontal line at the quarry top is a fault between upthrust Oriskany (?) and underlying Hamilton sandstones. The uppermost Silurian and Lower Devonian are presumed either to be mostly faulted out or to have been locally eroded or not deposited at this point.
5.0	The Tuscarora sandstone forms "Rockville Dam," a ledge crossing the river. It is exposed at low water.
5.4	Rockville. Walk east on the first street north of the stone arch bridge, turn right on road east of the abandoned canal and proceed south to the switch tower and thence along the east side of the tracks to a cut in the Lower Silurian sandstones and conglomerate, the gray Tuscarora formation. The top of the Martinsburg is concealed in this section. The very coarse conglomerate and stray red beds may represent the "feather edge" of the Juniata formation to be seen farther west. Next north along the track (all beds are overturned) are exposed the red sandstones of the Rose Hill formation. These are high in iron content and recognized by their many mud chips. The Tuscarora appears abnormally thin here. It may be observed, however, that it is cut by many low angle faults which hade north. Presumably

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[52] Pennsylvania Topographic and Geologic Survey: Geologic Map of Pennsylvania (1931).
E. W. Claypole: A preliminary report on the palaeontology of Perry County, Pa. Second Geol. Surv., vol. F2 (1885).
Pennsylvania Second Geological Survey, vol. X (1885) geologic maps of Cumberland, Dauphin and Perry counties, numbers 21, 23, and 45 respectively.

these have reduced its thickness materially. Continuing north along the railroad to the first road crossing, turn right up the valley.

South of the road, behind the houses, may be seen the Bloomsburg red shale. The Marcellus black shale (probably the Mahanoy member) is exposed in the quarry north of the road. This close proximity of Middle Silurian and Middle Devonian strata leaves little room for concealed Upper Silurian and Lower Devonian formations. In the abandoned quarry, the very hard, dark sandstone near the west end is the Rockville member of the lower Skaneateles. The adjacent sandstones and shaly beds are the lower part of the Montebello member and are of Skaneateles age.

Walking up the secondary road from the west end of the quarry, a second quarry is passed exposing part of massive Montebello sandstone in which occur a few invertebrates and plant fragments. The third and last quarry farther north exposes the upper part of the Montebello sandstone. The rock here is highly fossiliferous with a large fauna of Hamilton invertebrates. Toward the northern end is a pebbly zone with corals which is thought to represent the Centerfield limestone of New York and as such marks the base of the Ludlowville formation. The Montebello is thus seen to include the Skaneateles and Ludlowville formations of the Hamilton. It probably runs on into the Moscow, but the top is concealed here.

Returning to the highway, proceed north as before.

6.1 Crossing Fishing Creek. The stream occupies Upper Devonian shales, mostly in the lower part of the Catskill.

6.7 Hecks Station (Heckton). Across the railroad is an abandoned quarry in Catskill red and green sandstones and shales which carry plant fragments. This zone is correlated with the prominent Honesdale sandstone of the Catskill of northeastern Pennsylvania which is of Canadaway (post-Chemung) age.

6.9 The Catskill-Pocono contact is exposed on the railroad above the highway.

7.2 Large, walled-up spring right of road. By climbing the railroad embankment here, a fine section of the lower Pocono is to be seen in cuts. This is the Second Mt. member. It and the higher beds may be viewed across the river where they form the overturned south limb of Cove Mountain syncline.

8.0 Crossing Stony Creek. The Mauch Chunk red beds crop out along its banks, but the contact of the Mauch Chunk with the Pocono is hidden.

8.1 Dauphin village. Right fork up hill at fire station. The road crosses the Mauch Chunk red beds in the south limb of the Cove Mountain syncline.

9.0 Brick school. The crest of Third Mountain northeast of the school is the western extremity of the basal Pennsylvanian of the Southern Anthracite Field. It is an overturned syncline of Pottsville conglomerate overlying the Mauch Chunk red beds. The physiography here is spectacular. Cove Mountain swings around to the west uniting Second with Peters Mountain in a great bow. The even crests of these ridges may be seen as one stands here upon a lower level into which Clarks Creek has entrenched itself. Water gaps of the Susquehanna are conspicuous features.

The Pottsville may be studied by making a short side trip on foot from here. It is the only opportunity to see it in this area. Continue north along the road to the first curve, and then strike east across the fields and up along the nose of Third Mountain. The structure and lithology are clearly discernable, as also the prominent rock city which the nearly vertical, south limb of the syncline makes.

From the brick school the route should be retraced to Dauphin village whence the course is again north on U. S. Route 22, crossing the Mauch Chunk red beds of the Cove Mountain syncline. The approximate position of the synclinal axis may be determined by noting the change of dip in road cuts and the line of strike of the crest of Third Mountain.

10.9 Cuts here and for about three miles north show the Mauch Chunk red beds.

13.7 Speeceville. To the left across the railroad at the foot of the grade (Red Hill) are abandoned brick works which used river clays. At the right is a zone of calcareous nodules in the Mauch Chunk, an unusual feature in the monotonous succession of red sandstones and shales.

14.6 Underpass. Massive Pocono beds show in road cuts and along the railroad. This formation carries coal beds up to four feet thick. In the south face of Peters Mountain about 5 miles east of here they were formerly but unsuccessfully mined.

14.7 Across the river the Pocono is exposed in the face of Cove Mountain. South of Duncannon, the Catskill forms Pine Ridge. This part of the Catskill contains hard sandstones and conglomerates correlated with the Honesdale and Pimple Hill members farther east. The ridge is cut off from the north flank of Cove Mountain by a meander of Shermans Creek. East of the river, these hard Catskill beds form a prominent shelf along the north flank of Peters Mountain. They may also be seen at low water as ledges crossing the river.

16.2 Clarks Ferry Bridge. Turn left, crossing the Susquehanna River at its confluence with the Juniata River from the west.

16.7 At the west end of the bridge, bear right on U. S. Route 22 across Duncan "Island" and up the east bank of the Juniata. The "Island" is a floodplain developed at the confluence of the two rivers. This region was severely damaged in the floods of 1936. Across the Juniata to the west the distorted Catskill red beds may be seen in railroad cuts.

18.4 Amity Hall. Bear left on U. S. Route 22. The Catskill is abundantly exposed in road cuts. The occasional thick, green lenses seen are probably in part channel deposits and often include macerated plant fragments. In the lower portion of the Catskill may be seen very thin, green shales which carry marine Chemung fossils. They are the only marine Chemung remains recognized in this section. However, it should be noted that immediately west of here in Perry County two zones of Chemung invertebrates occur, Dellville and Kings Mill beds, in the lower 1000 feet of the Catskill.

19.5 Cut on right of road north of small gully. The vertical, yellowish to rusty band, 20 to 30 feet wide, in the midst of the red beds is a sill or dike of Triassic "diabase." The adjacent sediments are baked gray. This intrusive is believed to be continuous with the Ironstone Ridge dike to the southwest in Cumberland County.

20.2 Road cuts expose chocolate-colored beds underlying the base of the Catskill red strata. These probably equal the Parkhead of the highest Portage in Maryland.

20.5 High rock cut along road. The cliff is Trimmers Rock sandstone with an "Ithaca" fauna. Storm rollers and fossiliferous bands may be observed.

20.8–21.0 Starting at the south end of a series of cuts from the first gully north of the cliff of Trimmers Rock sandstone at the last stop, the lower Portage shales may be studied in a complete sequence. At the north side of the gully is the Losh Run shale with a "*Cladochonus-Reticularia laevis* zone" correlated with that of the Maryland Portage. The type locality for the Losh Run is directly westward across the river. Immediately below the Losh Run is one of the most contorted sections in this part of the State. It consists of folded and crushed greenish shales and sandstones, the eastward, attenuated, arenaceous edge of the thick Brallier shale of Blair and Bedford counties. Descending farther northward, the dark gray Harrel shale and some sandstone with a fairly abundant Naples fauna is exposed. This is underlain by 200 feet of the black, fissile Burket ("Genesee") shale, in which almost the only fossils found are *Styliolina* and *Buchiola.* At the base of the Burket, about ten feet south of the next gully opening east from the river, may be seen a few feet of Tully shale and limestone nodules with a characteristic fauna. The Tully rests disconformably upon the highest Hamilton shale, the Moscow, which contains *Vitulina* and other fossils.

21.1 Crossing Hamilton sandstones and shales. The Montebello is somewhat thinner and less massive here than at Rockville. It passes over entirely to shale and thin sandstones farther up the river. Here the sandstone supports Half Falls Mountain (an anticline) and the next ridge south, Dicks Ridge, which is a fault block thrust north along the great Perry County fault.

21.4 The valley to the east is downfolded Burket and upper Hamilton shales.

21.8 East of the road, the large talus slope is composed of blocks of Montebello sandstone.

22.2 Immediately south of a limekiln a secondary road may be followed up the bank on foot. This leads to a quarry in the Onondaga formation of black limestone which is overlain in the quarry face by the black Marcellus shale. The two are separated by a thin band of sandstone which is thought to indicate a local disconformity; these formations are usually transitionally related. Neither formation contains many fossils here. Returning to the road and walking north about 150 yards, an exposure of the upper Oriskany (Ridgeley) pebbly sandstone replete with large *Spirifer* casts is seen.

Immediately north of this outcrop is a small gully leading into the core of Half Falls Mountain. At the end of the gully is a small cave in the New Scotland limestone, highest member of the Helderberg group. It forms the north wall of the gully and is faulted against a chert which forms the south wall. This chert was formerly correlated with the Shriver, but the junior author's recent studies place it in the upper New Scotland.

22.4 The Oriskany is once more seen in the north limb of the anticline.

This station marks the northern terminus of the trip. From here the route may be retraced to Clarks Ferry Bridge, a distance of 5.7 miles.

28.1 Approaching Clarks Ferry Bridge. Bear right at the triangle at the west end of the bridge onto State Highway 33 to Duncannon.

After passing through Duncannon, cross the railroad and turn left (south) onto State Highway 5 which runs south along the west bank of the Susquehanna River.

30.1 Crossing Sherman Creek. Along the north bank to the right, the large dip-slope exposure is in the Catskill.

30.9 After passing cuts in Cove Mountain, a stop may be made where a secondary road runs abruptly up grade to the right. Up this road is an abandoned quarry in the basal Mauch Chunk red beds. By walking back (north) along Route 5, a splendid section of the upper Pocono, Cove Mountain, is seen with its conglomerates, sandstones, shale, coaly beds and fossil plants. Note the normal (south) dip of the beds here as contrasted with the overturned beds of the south limb of the Cove Mountain syncline.

Continuing south the road crosses the Mauch Chunk of the Cove Mountain syncline. A zone of calcareous nodules is exposed where the new highway branches from the old road. It may be correlated with that seen at Speeceville.

36.3–36.6 Crossing Second Mountain. Across the river a splendid view is had of the transected edges of the Pocono, overturned to the north with its three divisions, the massive, pebbly upper (Cove Mountain) member, the similar lower (Second Mountain) member, and the platy middle (Peters Mountain) member.

37.7 Continuing south through Marysville, the road passes the end of Little Mountain near the end of the stone arch railroad bridge. Cuts expose well the Montebello sandstone which supports this small ridge north of Kittatinny Mountain. A large idle quarry west of the road is in this sandstone. At the west end of the quarry a trail may be followed to the top of the wall where Oriskany (?) is exposed which has been described as faulted up on top of the Montebello. At the south of the quarry the Marcellus black shale shows with many specimens of *Taonurus.*

Continuing south, road cuts expose the Middle and Lower Silurian and Upper Ordovician in Kittatinny Mountain. Passing signs of the Bloomsburg red shale and the Rose Hill sandstones, the latter supporting the crest of the mountain, a large cut shows the basal Silurian, Tuscarora or Shawangunk formation, of gray, pebbly sandstone. *Arthrophycus* may occur sparingly. The gray beds rest upon red Juniata sandstone, shale and conglomerate. The weakly-cemented, red conglomerate is particularly well developed here. Beneath the red beds is a few feet of gray sandstone and conglomerate assigned to the "Oswego" formation. This rests directly upon the Martinsburg shale which is fossiliferous to the topmost bed.

41.5 Just before ascending the grade to a hill with a reservoir and standpipe at its top, a stop may be made. Walk south along the abandoned street car grade to cuts and also visit the adjacent section below on the railroad. Here is exposed a limestone interbedded in the Martinsburg shale. It is a barren, highly variable member; platy limestone including dark shale partings, massive beds of edgewise conglomerate or breccia, oölitic and sandy, cross-bedded strata. Many beds are rippled. At the south end of this exposure the limestone is in conformable contact with the red and olive-gray (buff-weathering) Martinsburg shale.

A study of the ripple marks and truncation of the cross-bedding indicates how the limestone is related to other closely compressed strata. It is one of several local limestone lenses included in the Martinsburg between the Susquehanna and Schuylkill valleys.

Continuing south, cuts expose red and non-red Martinsburg shales.

42.8 The railroad tracks east of the highway occupy an abandoned channel thought to have been occupied by the Conodoguinet Creek which now flows into the Susquehanna south of West Fairview. The prominent hill between the railroad yards and the river is supported by heavy Martinsburg sandstones with interbedded graptolite-bearing shales. This topographic expression is exceptional, since most of the Martinsburg sandstones appear to have calcareous cement and break down rather rapidly.

43.1 West Fairview. Sharp right up grade into Fairview Avenue at filling station. Turn left at end of street at street car tracks along concrete highway (State Highway 944) and continue southeast to return to State Highway 5. On the right is the valley of the Conodoguinet Creek, a classic example of entrenched meanders.

43.4 Continue south on State Highway 5.

44.0 Crossing the mouth of Conodoguinet Creek.

45.9 Bridgehead to Harrisburg. West of the highway opposite the bridgehead in a deep railroad cut, the basal Martinsburg beds transitional with the underlying limestone (Chambersburg?) may be seen. Platy limestone in the lower Martinsburg suggests the limestone seen to the north interbedded with the shale. However, in this case the shale grades down into the limestone which in turn becomes purer and fossiliferous. There are important differences between the limestone beneath the Martinsburg and those interbedded in the shale. Thus, that at the base carries large phenoclasts of massive, often sandy limestone presumably derived from the Beekmantown. The relative amounts of shale and limestone are different, the basal limestone lacks breccia (edgewise conglomerate) and oölite. This section is also interesting as showing the degree of crushing and alteration which the lower Martinsburg has undergone.

To the south across the highway, the massive Beekmantown limestone shows in railroad cuts.

45.9 Bridges to Harrisburg. Turn left across Susquehanna River.

46.7 Harrisburg. Right at the east end of the bridges and continue south on Route 230 toward Lancaster and Philadelphia through Steelton.

47.7 South end of Harrisburg. Large cuts along the east side of the highway expose the Beekmantown limestone; the massive beds are distorted by numerous folds.

48.2 Additional exposures of the Beekmantown limestone are to be seen in abandoned quarries east of the highway. The structure is interesting.

50.8 Opposite the south end of the Steel Plant, turn sharp left into a side street which leads to Oberlin.

51.0 Where the road starts up grade, cuts at junction with a secondary road south expose the base of the Martinsburg shale or the Chambersburg platy limestone and shale in contact with massive limestone. These platy beds carry graptolites. Slipping along the bedding surfaces has smeared the fossils to several times their normal dimensions.

From here turn back to Route 230.

51.3 South edge of Steelton. The large quarry east of the highway exposes interesting structures in the Beekmantown limestone.

51.6 Cuts east of highway. This is the southernmost exposure of the massive Beekmantown seen on the section; between here and the next cut is concealed the contact with the Triassic.

51.9 Cuts east of highway. Triassic sandstones, shales and conglomerates (fanglomerates) are exposed for some distance. Continue south through Highspire.

54.6 Right into secondary road crossing railroad by overhead bridge.

54.8 Left after crossing railroad by overhead bridge. West of the road in a large sand and gravel pit may be seen outwash gravels. The cobbles in these gravels are interesting because it is possible to identify the formation from which they came.

SUPPLEMENTARY SIDE TRIPS

The foregoing itinerary includes all of the more important and interesting localities to be seen from Highspire on the south to Half Falls Mountain on the north, covering both sides of the Susquehanna River from Harrisburg to Clarks Ferry and east of the Juniata above the latter place. A few other localities within easy reach are well worth visiting because they supplement the stations already denoted.

Reservoir Hill. This high hill, a small monadnock, in the eastern part of Harrisburg is reached by driving east on Market Street or U. S. Route 22 along State Street. The hill is supported by the Paxton Creek conglomerate, a member of the Martinsburg, unique in this region.

Wildwood Park. In the northern end of the City of Harrisburg is situated Wildwood Park which may be reached by driving north on Cameron Street. In the park, north of it and to the east are many exposures of the Martinsburg formation, particularly the interesting limestone lenses which it carries. After seeing the limestone at Enola, a visit to the Wildwood Park localities is instructive for comparison.

U. S. Route 22 cut-off. This road runs southeast across the north part of Harrisburg. The road cut in the ancient river bank near the State Hospital exposes the Martinsburg shale capped by high terrace river gravels.

Central Perry County.[53] In order to observe the higher marine beds of the Silurian and the Helderberg group below the New Scotland, a trip through Perry County is necessary. By following U. S. Route 22 beyond Half Falls Mountain to Newport and then taking Route 5 west to New Bloomfield and thence southeast to Duncannon, exposures of these beds may be seen in road cuts and quarries. An interesting cut in the Oriskany and Middle Devonian is observable on the railroad east of New Bloomfield. A variant of this trip is to leave Route 5 south of New Bloomfield and follow Route 33 to Sterretts Gap. Here is a fine exposure of the Juniata and Tuscarora. Small cuts south of the gap at the base of the grade are in fossiliferous Martinsburg.

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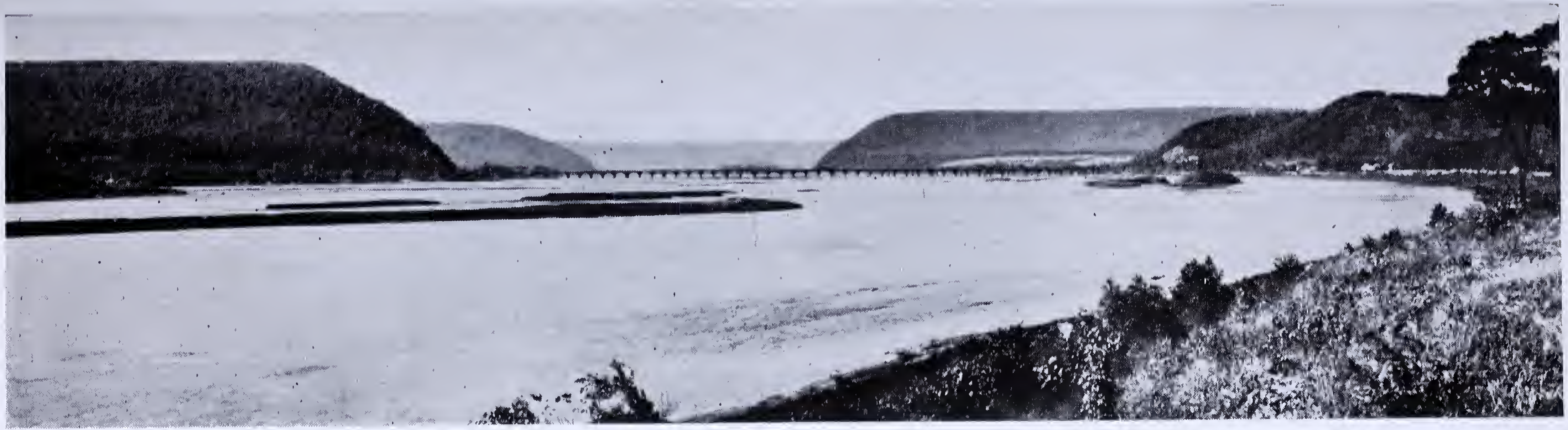
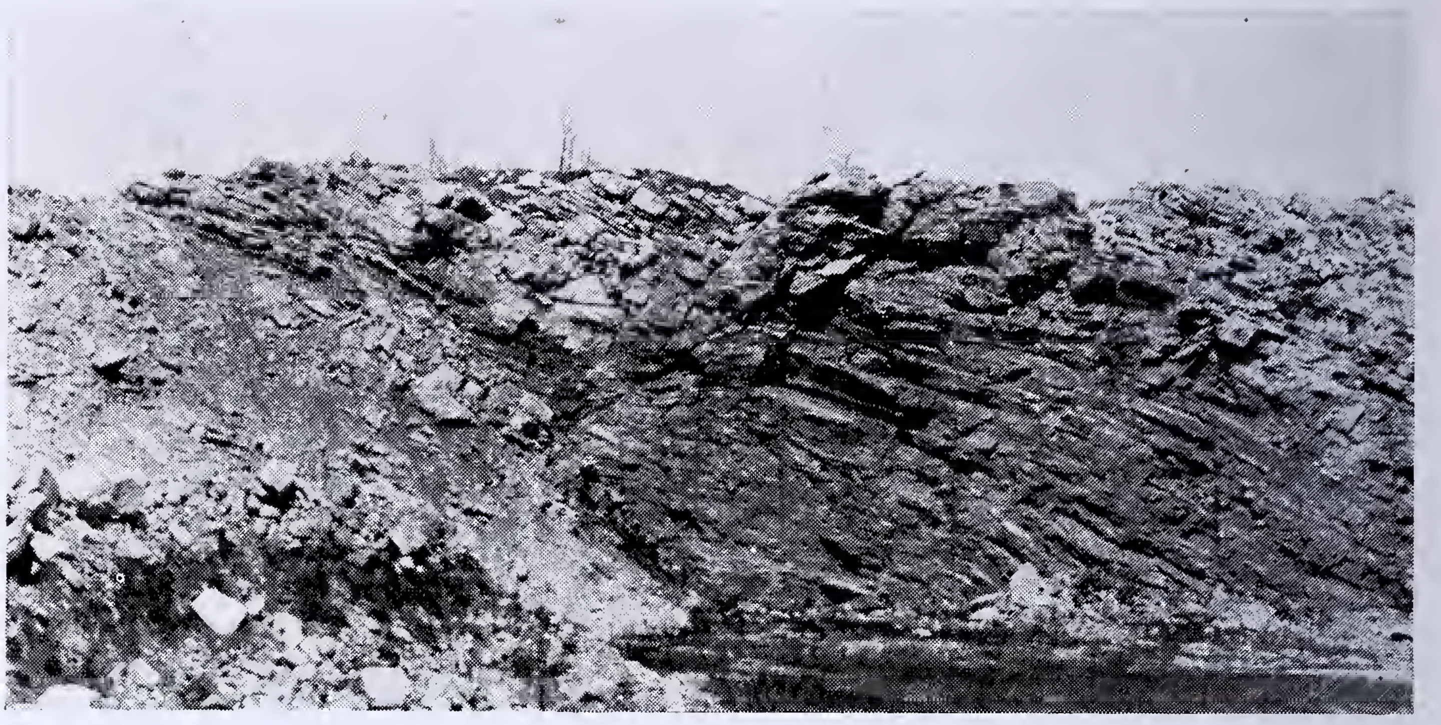
[53] J. B. Reeside: The Helderberg limestone of central Pennsylvania, U. S. Geol. Surv., Prof. Paper 108K (1918).
C. K. Swartz and F. M. Swartz: Early Silurian formations in southeastern Pennsylvania, Geol. Soc. Am., Bull., vol. 42 (1931) pp. 621-662.

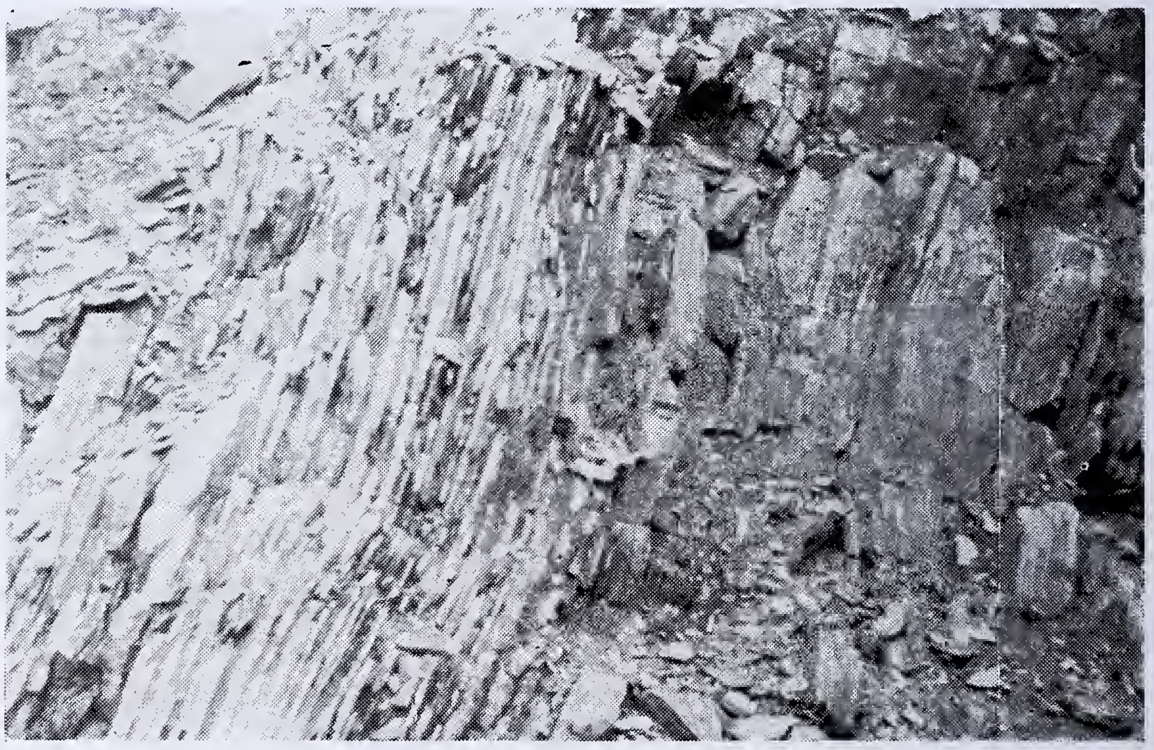


A. SUSQUEHANNA WATER GAP IN KITTATINNY MOUNTAIN FROM THE SOUTH
Kittatinny Mountain is held up by the Tuscarora and Rose Hill formations. Beyond the stone arch bridge is Second Mountain (Pocono sandstone). The most distant ridge is Peters Mountain (Pocono sandstone). Second and Peters mountains are limbs of the Cove Mountain syncline.
Photograph by Stanley W. Lohman

B. SUSQUEHANNA WATER GAP IN PETERS MOUNTAIN
The photograph taken from near Dauphin shows Peters Mountain (Pocono sandstone) right, and Cove Mountain (Pocono sandstone) left, forming the opposite sides of the gap. The low ground in the middle distance consists of Mauch Chunk red beds in the Cove Mountain syncline.
Photograph by George H. Ashley



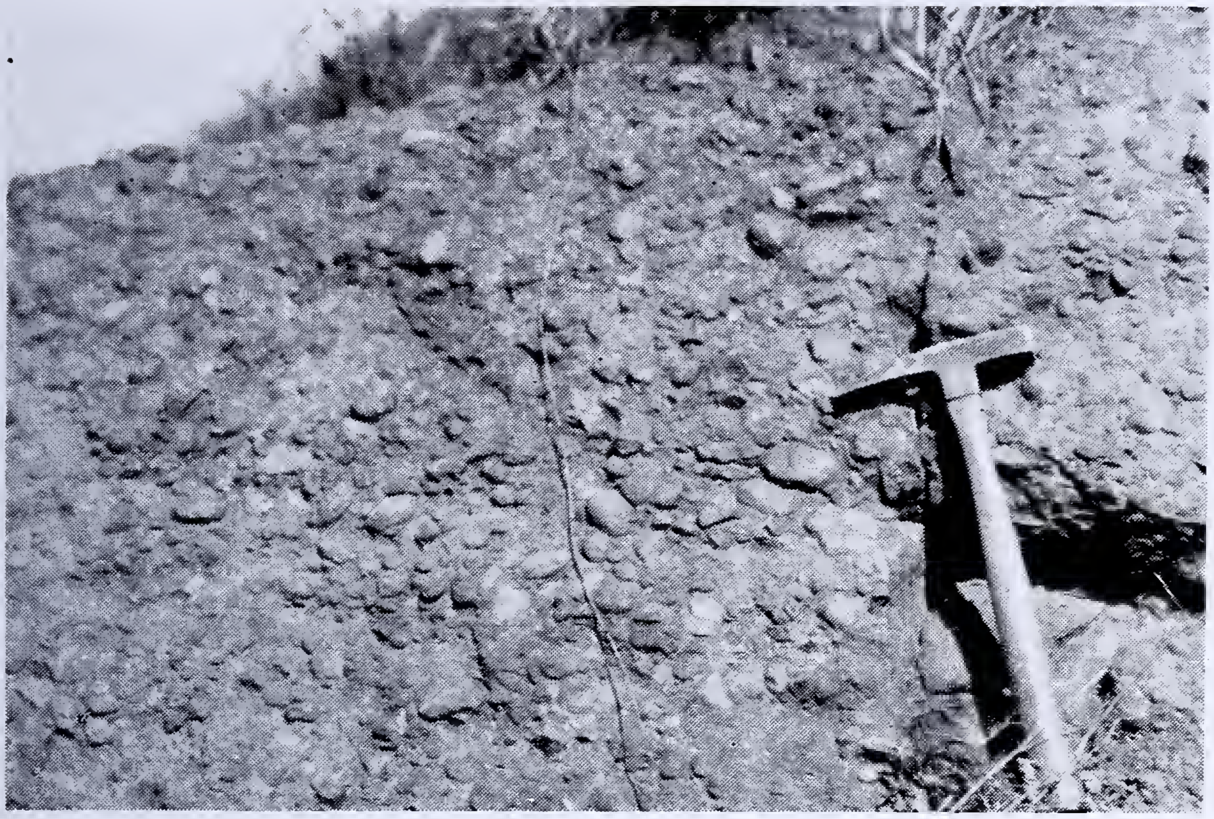
A. BEEKMANTOWN LIMESTONE QUARRY AT STEELTON
The Beekmantown limestone is here faulted and folded.



B. LIMESTONE INTERBEDDED WITH THE MARTINSBURG SHALE
This limestone in a section near Enola on the railroad is a barren, highly variable member consisting chiefly of platy limestone with dark shale partings.

Photographs by Bradford Willard

PLATE 4



A. CONGLOMERATE AT THE BASE OF THE SILURIAN AT ROCKVILLE

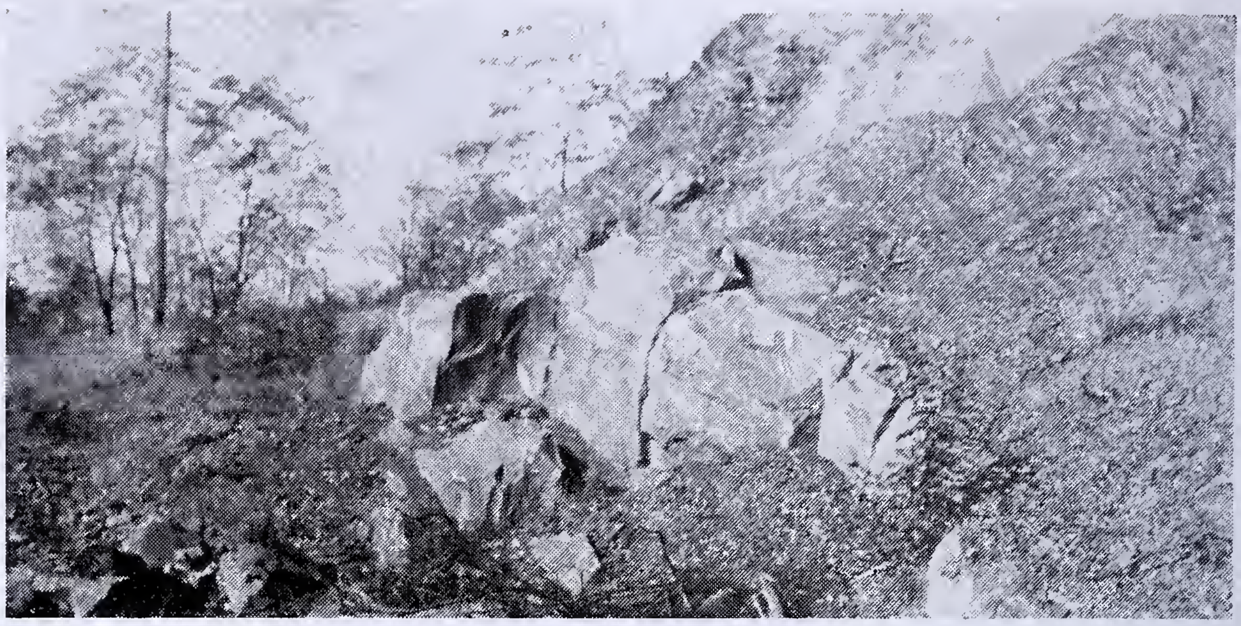
On the railroad at Rockville the very coarse conglomerate and stray red beds at the base of the Silurian may represent the "feather edge" of the Juniata red beds farther west.

Photograph by George H. Ashley

B. TUSCARORA FORMATION AT ROCKVILLE

The Juniata (?) conglomerate faulted against the locally thin Tuscarora formation which is overturned north (to the left) the beds dipping steeply south.

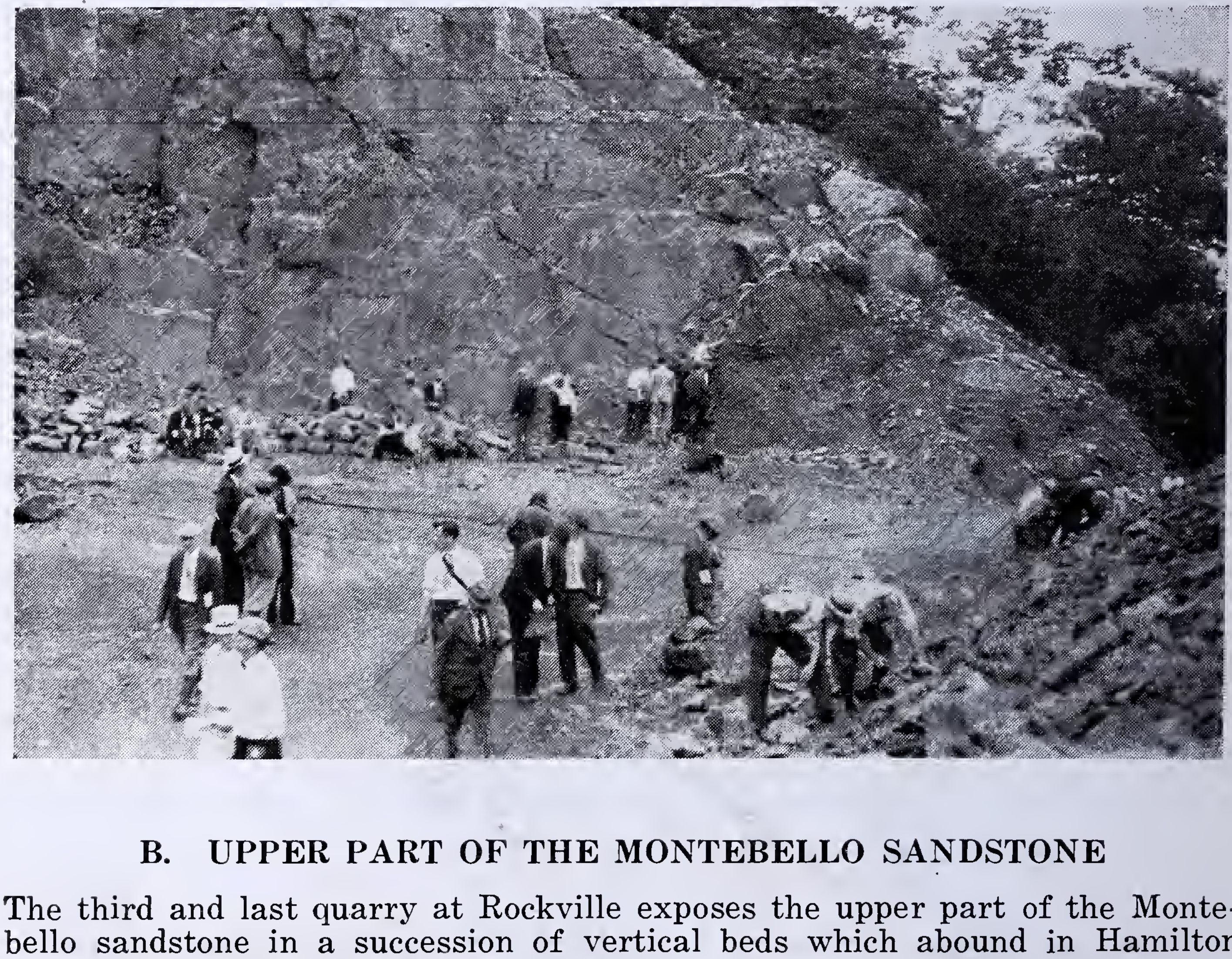
Photograph by Bradford Willard



A. ROCKVILLE MEMBER OF THE SKANEATELES FORMATION

In the first quarry at Rockville the very hard, dark sandstone near the west end is the Rockville member of lower Skaneateles age.

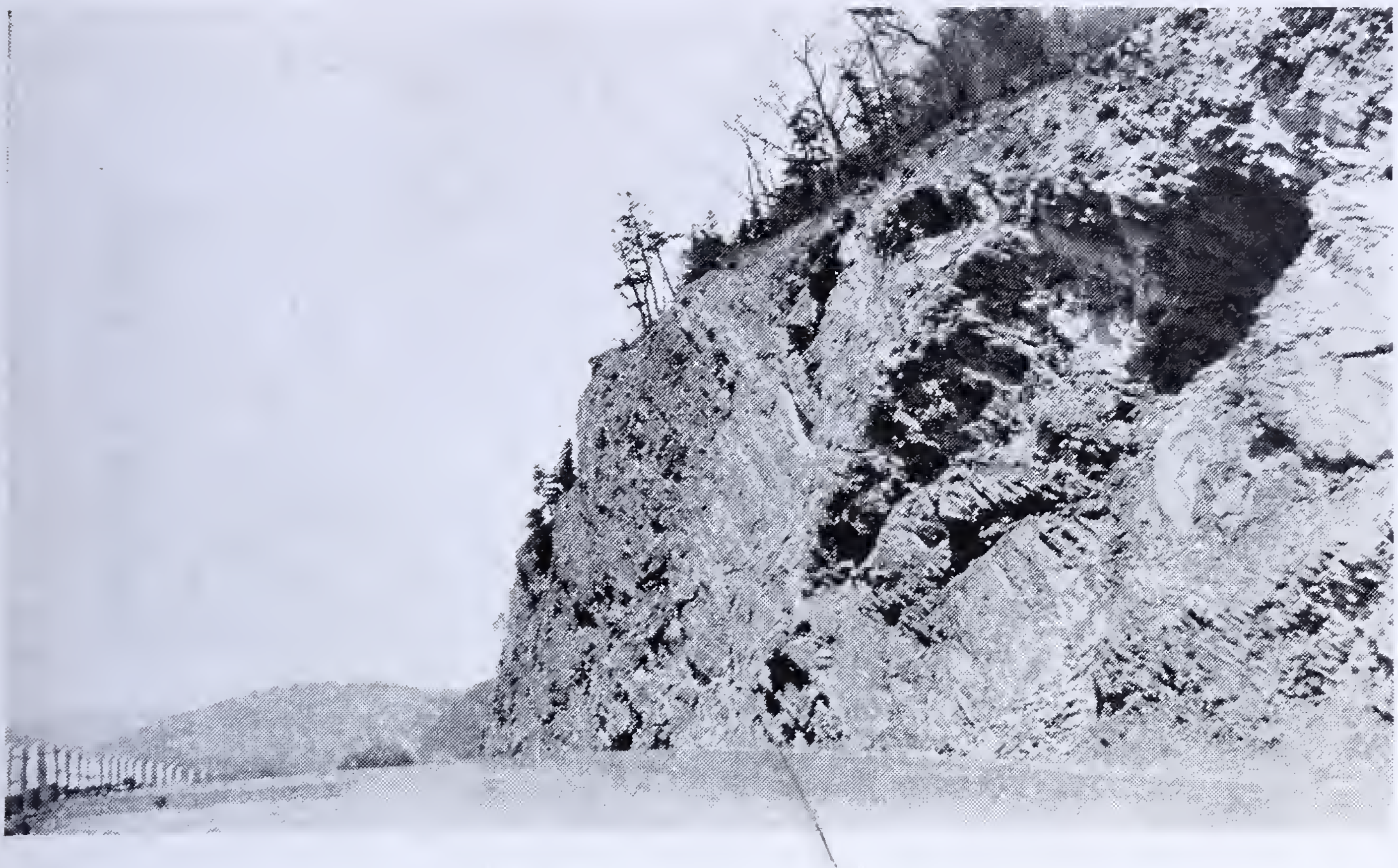
Photograph by Bradford Willard



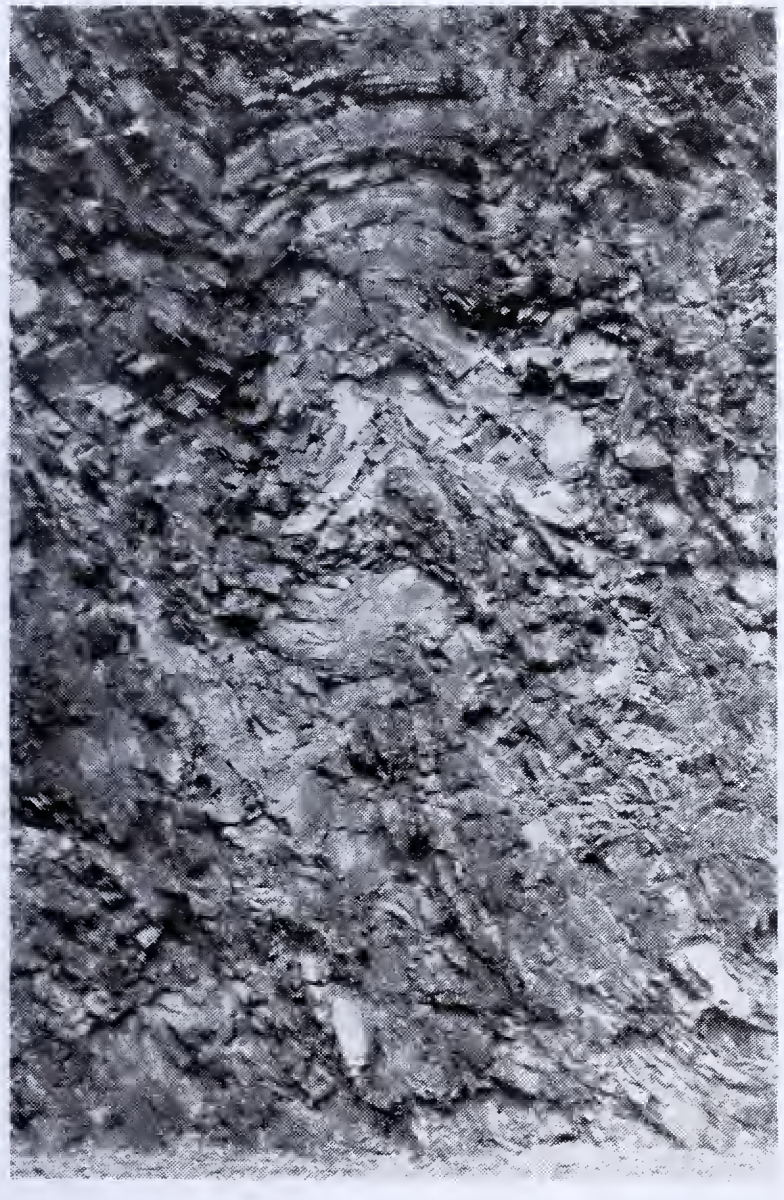
B. UPPER PART OF THE MONTEBELLO SANDSTONE

The third and last quarry at Rockville exposes the upper part of the Montebello sandstone in a succession of vertical beds which abound in Hamilton fossils. The photograph shows a party of the Field Conference of Pennsylvania Geologists in the quarry.

Photograph by George H. Ashley

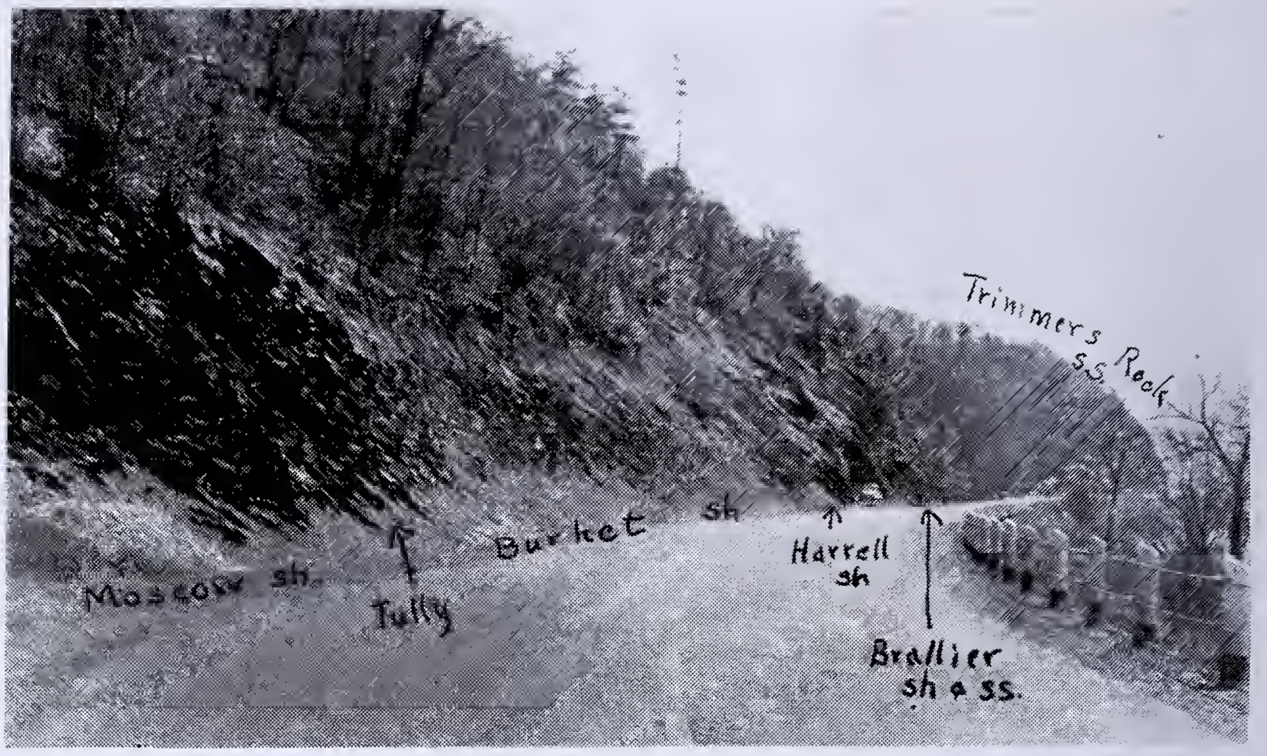


A. TRIMMERS ROCK SANDSTONE
The high artificial cliff on the Juniata between Amity Hall and Half Falls Mountain exposes the Trimmers Rock sandstone with an "Ithaca" fauna. Storm roller bands may be observed here.



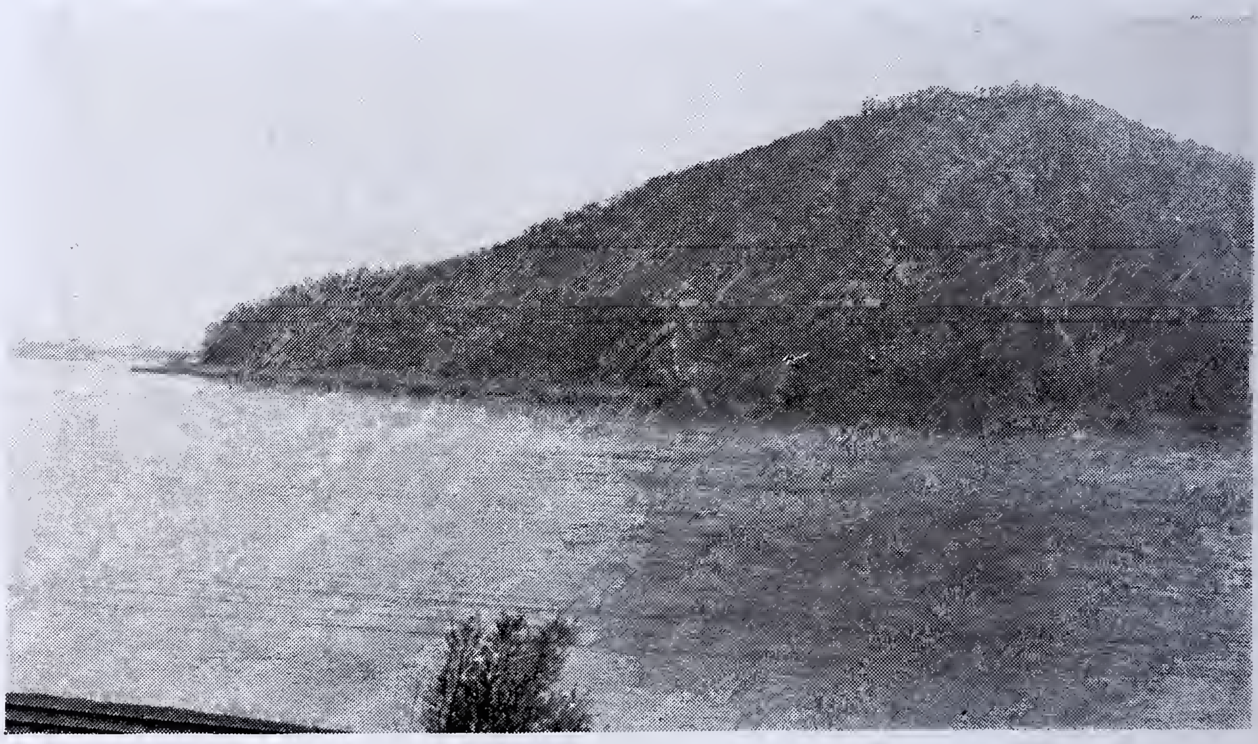
B. BRALLIER SANDSTONE AND SHALE
On the Juniata River immediately below the Losh Run shale are sandy and shaly beds assigned to the Brallier. They occur in one of the most contorted sections in this part of the State. *Photographs by George H. Ashley*

PLATE 7



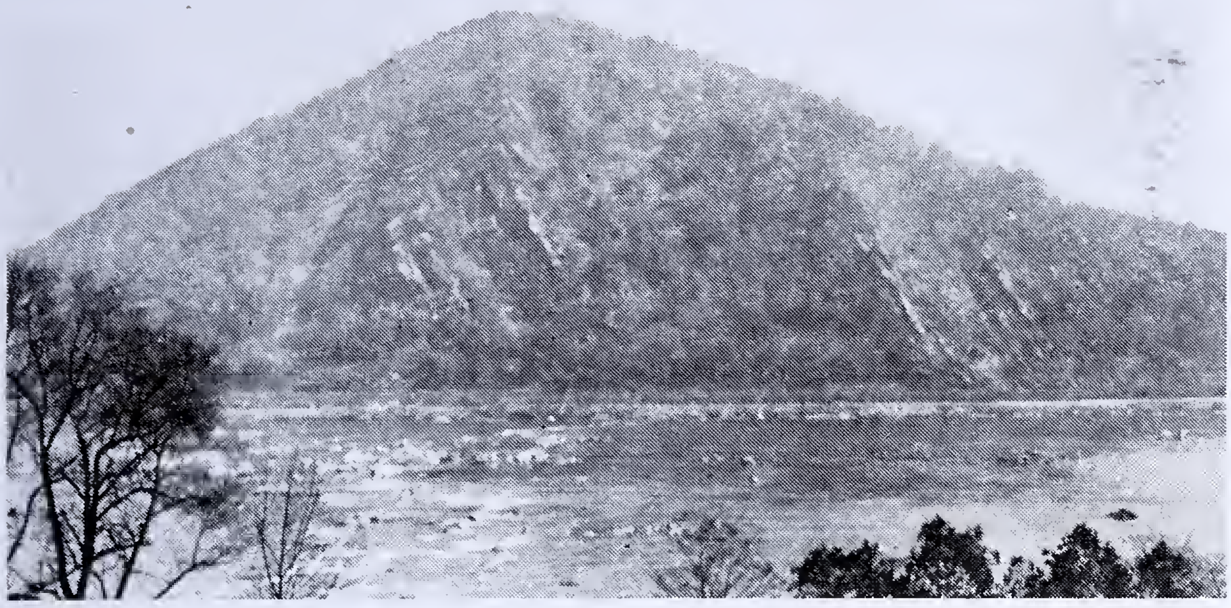
A. MOSCOW, TULLY, BURKET, HARRELL, AND BRALLIER

Descending in section northward the dark Harrell shale and some sandstone, the underlying 200 feet of Burket ("Genesee") black shale, the thin Tully and the top of the Hamilton show in a long cut.



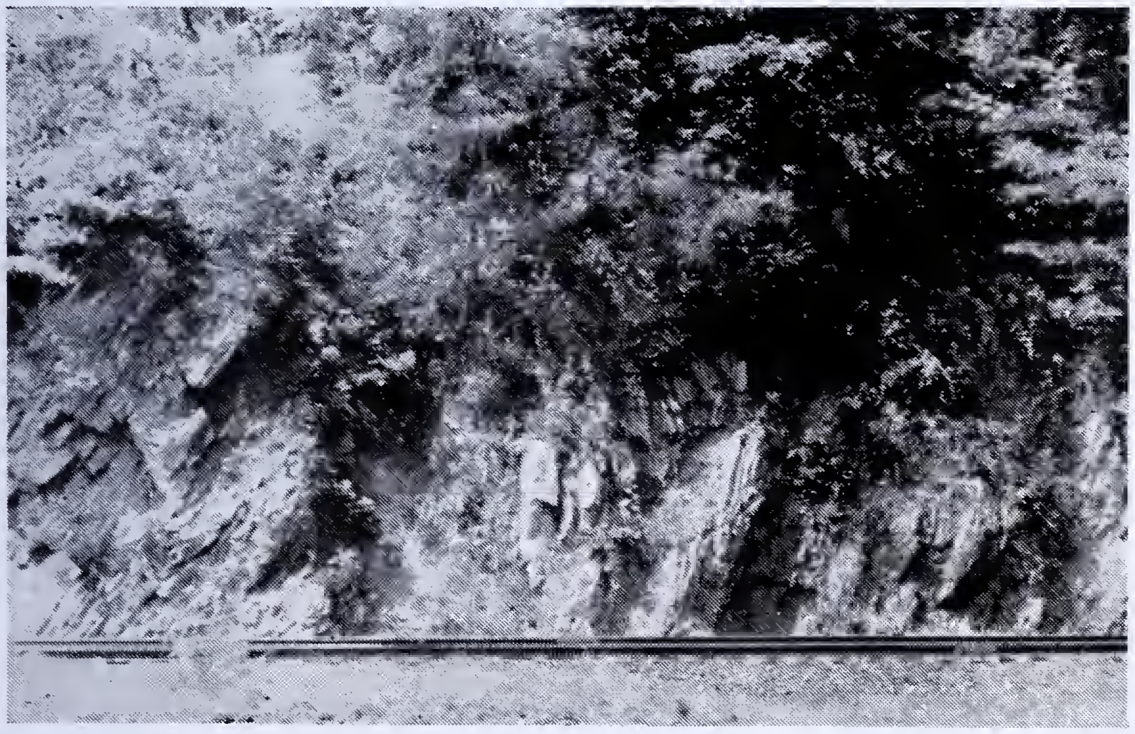
B. BENCH FORMED BY HONESDALE MEMBER OF CATSKILL

In the upper Catskill are hard sandstones correlated with the Honesdale and Pimple Hill members of the Catskill of northeastern Pennsylvania. East of the Susquehanna River at Clarks Ferry these beds form a prominent shelf along the north flank of Peters Mountain. *Photographs by Bradford Willard*



A. POCONO SANDSTONE IN SECOND MOUNTAIN

Crossing Second Mountain along the west side of the Susquehanna, a splendid view is had across the river of the transected edges of the Pocono, overturned to the north (left). The three divisions show clearly: the massive, pebbly upper Cove Mountain member forms the ledges below the crest; the similar, lower Second Mountain member forms the ledges at the right. The intervening, forested space is occupied by the platy, middle member, the Peters Mountain.

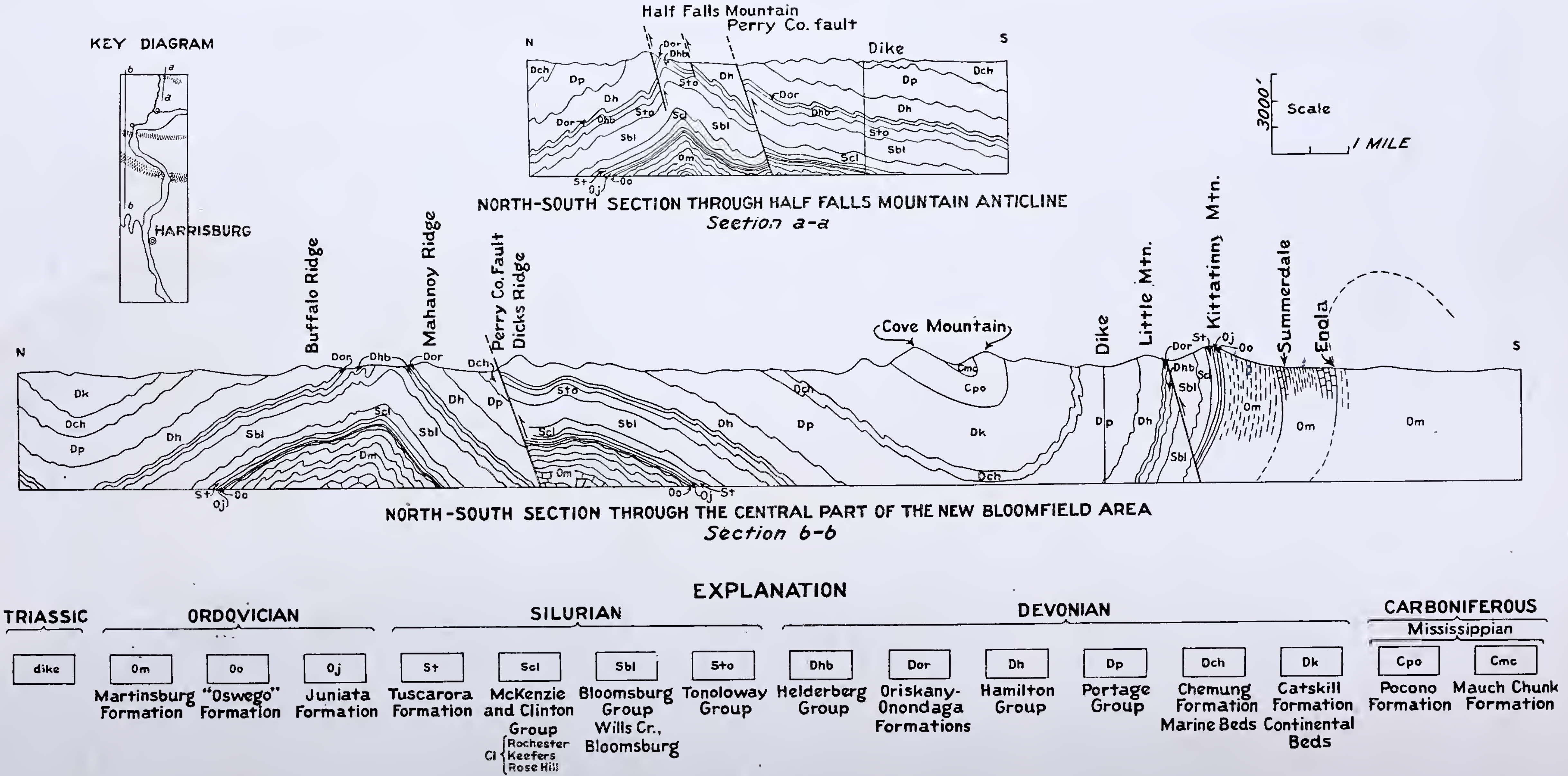


B. BASAL MARTINSBURG BEDS TRANSITIONAL WITH THE UNDERLYING LIMESTONE (CHAMBERSBURG?)

This section in Lemoyne is west of the highway opposite the bridgehead to Harrisburg. Platy limestone shown in a deep railroad cut suggests that seen among the shales near Enola, but the two are distinct. The basal beds include large phenoclasts of massive limestone presumably derived from the Beekmantown.

Photographs by Bradford Willard

PLATE 9



KEY DIAGRAM

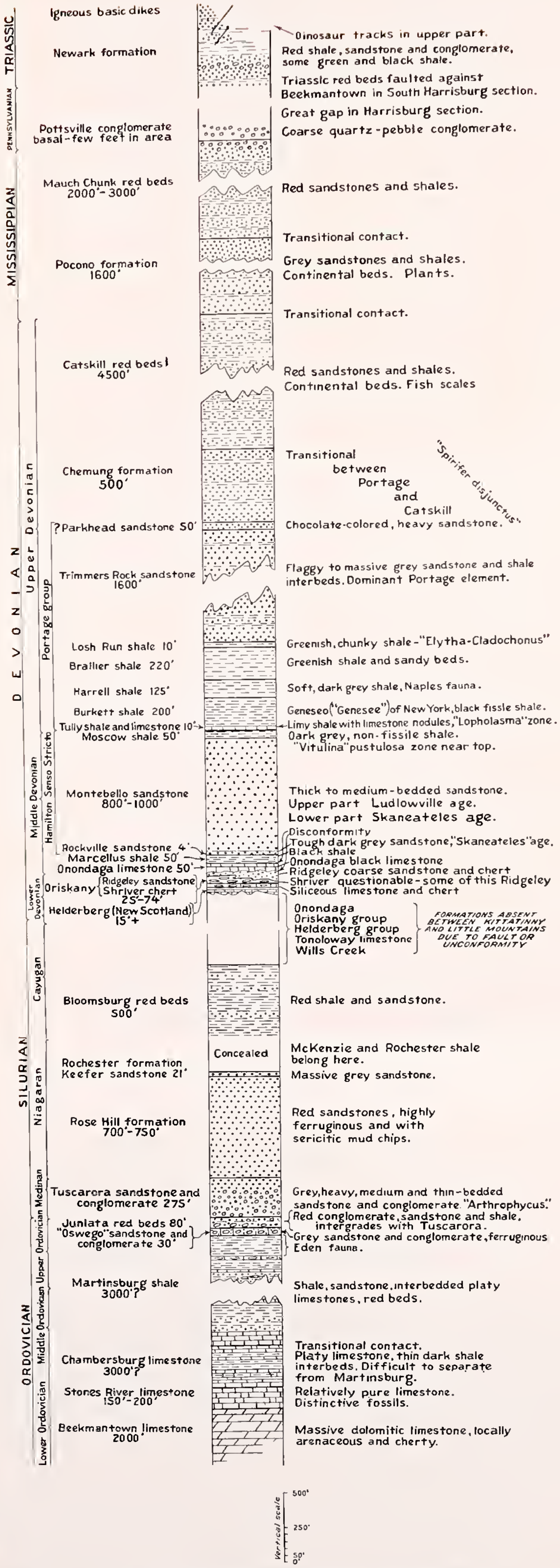
NORTH-SOUTH SECTION THROUGH HALF FALLS MOUNTAIN ANTICLINE
Section a-a

NORTH-SOUTH SECTION THROUGH THE CENTRAL PART OF THE NEW BLOOMFIELD AREA
Section b-b

EXPLANATION

STRUCTURE SECTIONS

PLATE 10


TRIASSIC
PENNSYLVANIAN
MISSISSIPPIAN
DEVONIAN
Upper Devonian
Portage group
Middle Devonian
Hamilton Senso Stricto
Lower Devonian
SILURIAN
Cayugan
Niagaran
Medinan
ORDOVICIAN
Upper Ordovician
Middle Ordovician
Lower Ordovician
Igneous basic dikes
Newark formation
Dinosaur tracks in upper part.
Red shale, sandstone and conglomerate, some green and black shale.
Triassic red beds faulted against Beekmantown in South Harrisburg section.
Great gap in Harrisburg section.
Pottsville conglomerate basal-few feet in area
Coarse quartz-pebble conglomerate.
Mauch Chunk red beds 2000'-3000'
Red sandstones and shales.
Transitional contact.
Pocono formation 1600'
Grey sandstones and shales. Continental beds. Plants.
Transitional contact.
Catskill red beds 4500'
Red sandstones and shales. Continental beds. Fish scales
Chemung formation 500'
Transitional between Portage and Catskill
"Spirifer disjunctus."
?Parkhead sandstone 50'
Chocolate-colored, heavy sandstone.
Trimmers Rock sandstone 1600'
Flaggy to massive grey sandstone and shale interbeds. Dominant Portage element.
Losh Run shale 10'
Greenish, chunky shale-"Elytha-Cladochonus"
Brallier shale 220'
Greenish shale and sandy beds.
Harrell shale 125'
Soft, dark grey shale, Naples fauna.
Burkett shale 200'
Geneseo ("Genesee") of New York, black fissle shale.
Tully shale and limestone 10'
Limy shale with limestone nodules, "Lopholasma" zone.
Moscow shale 50'
Dark grey, non-fissile shale. "Vitulina" pustulosa zone near top.
Montebello sandstone 800'-1000'
Thick to medium-bedded sandstone. Upper part Ludlowville age. Lower part Skaneateles age.
Disconformity
Rockville sandstone 4'
Tough dark grey sandstone, "Skaneateles" age.
Marcellus shale 50'
Black shale
Onondaga limestone 50'
Onondaga black limestone
Oriskany
Ridgeley sandstone
Ridgeley coarse sandstone and chert
Shriver chert 25'-74'
Shriver questionable-some of this Ridgeley
Helderberg (New Scotland) 15'+
Siliceous limestone and chert
Onondaga
Oriskany group
Helderberg group
Tonoloway limestone
Wills Creek
FORMATIONS ABSENT BETWEEN KITTATINNY AND LITTLE MOUNTAINS DUE TO FAULT OR UNCONFORMITY
Bloomsburg red beds 500'
Red shale and sandstone.
Concealed
Rochester formation
McKenzie and Rochester shale belong here.
Keefer sandstone 21'
Massive grey sandstone.
Rose Hill formation 700'-750'
Red sandstones, highly ferruginous and with sericitic mud chips.
Tuscarora sandstone and conglomerate 275'
Grey, heavy, medium and thin-bedded sandstone and conglomerate. "Arthrophycus."
Juniata red beds 80'
Red conglomerate, sandstone and shale, intergrades with Tuscarora.
"Oswego" sandstone and conglomerate 30'
Grey sandstone and conglomerate, ferruginous Eden fauna.
Martinsburg shale 3000'?
Shale, sandstone, interbedded platy limestones, red beds.
Chambersburg limestone 3000'?
Transitional contact. Platy limestone, thin dark shale interbeds. Difficult to separate from Martinsburg.
Stones River limestone 150'-200'
Relatively pure limestone. Distinctive fossils.
Beekmantown limestone 2000'
Massive dolomitic limestone, locally arenaceous and cherty.
Vertical scale
500'
250'
50'
0'

COLUMNAR SECTION ON SUSQUEHANNA—JUNIATA RIVERS
BETWEEN HALF FALLS MOUNTAIN AND HIGHSPIRE